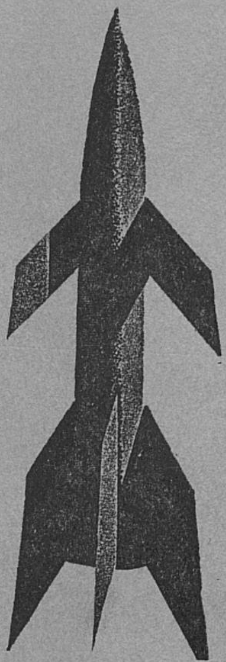
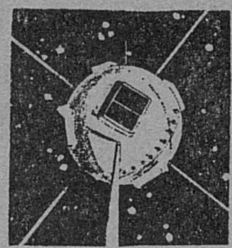
Commonwealth of Kentucky

EDUCATIONAL BULLETIN



SCIENCE EDUCATION



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FOREWORD

This bulletin has been prepared by the staff of the Division of Instructional Services, Bureau of Instruction, to provide assistance to administrators and teachers of science in our Kentucky schools.

Science, with its tremendous impact upon the world today, makes it imperative that we consider scientific methods an essential part of the general education of our children. Our schools must provide opportunities through an interesting and challenging program in this important field from the first through the twelfth grade if we are to meet the demands of a modern society.

I acknowledge with much appreciation the intensive work of the members of my staff and the special contributions of consultants at the local school level for the time and effort involved in preparing this bulletin. It is hoped that the material herein will be useful to the members of the profession as they strive to improve opportunities in science education for the youth of the Commonwealth.

WENDELL P. BUTLER
Superintendent of Public Instruction

CONTENTS

INTRODUCTION

Today the world of science is being stressed more than ever before. Try to visualize taking away for one week or even one day those things that are in constant use as a result of scientific improvement. The world is becoming more complicated each day because of scientific discoveries.

Children must have at least some general conception of this complex environment in which they live. At the same time, the science talented pupils must be trained to start where the older scientists stop.

No attempt was made in this publication to give an outline of subject matter in detail, only general, since selection of content material differs with various schools and can be best arrived at by individuals with first-hand knowledge of the needs, aptitudes, and interests of the pupils and of the local resources available.

It is hoped that the philosophy of "Doing Science" rather than just reading or talking about it will be adopted by all teachers, grades one through twelve. If science is to be learned efficiently, it must be experienced. It is so closely related to the life of every boy and girl that it is absurd to confine its study to reading a textbook alone or listening to a teacher lecture about it all the time.

An attempt has been made in this publication to supply information that will be of value to the administrators and teachers in the form of an organization guide and source manual. More emphasis has been placed on the organization and teaching of elementary science than any other area since it is evident that most of the elementary teachers need and must have help in this relatively new adventure in teaching. No doubt there has been more science equipment and supplies purchased for the Kentucky schools in the past two years than ever before due to the National Defense Education Act, Title III. The big problem now is to get this equipment used effectively. Just reading this section on Teaching Elementary Science will not make better teachers of science, but it is hoped that trying some of the ideas and adopting them to the local needs will help. The teacher's enthusiasm will be expanded as the enthusiasm of the children develops.

Other areas included in this publication are: New Trends in Science Teaching, What Constitutes a Creditable High School Course in Science, A Comparative Study of the Science Program in Kentucky

1957-1960, and List of Equipment and Supplies for the Various Science Courses Offered.

People from all walks of life are becoming more aware of the important role of science in our lives and in our National Security. They expect the schools to do something about this so called "Scientific Inferiority" which is discussed so much. This will take the cooperative efforts of teachers, principals, superintendents, teacher training institutions, and the State Department of Education, along with the aid of local, state, and federal governments.

H. M. WATKINS, *Supervisor of Science Instruction*, Western Kentucky
A. L. BERRY, *Supervisor of Science Instruction*, Eastern Kentucky

ACKNOWLEDGEMENTS

Science has no boundaries. The vast store of human knowledge is not confined to any person or small group of persons. To give credit to all who have contributed to the preparation of this bulletin would be impossible. Many have given advice and information regarding what is most needed at this time by administrators and teachers of science. Credit and appreciation are especially due to:

Dr. Denver Sloan, University of Kentucky. For personal help and suggestions.

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Mr. Donald E. Elswick, Director, Division of Research, State Department of Education.

Mr. Roy G. Smith, Coordinator of National Defense Education Act.

I

THE ROLE OF THE SCHOOL ADMINISTRATION IN THE SCIENCE PROGRAM

The science program must depend upon the support and attitude of the superintendent of schools, if there is to be an increased emphasis placed upon the teaching of science in the public schools of Kentucky. The improvement of the science program should be one of his very serious responsibilities as an administrator. The vast majority of the superintendents in the state are very enthusiastic about having a good science program, and as a result, much interest, enthusiasm, and inspiration has been reflected through patrons, pupils, and teachers.

The superintendent, together with the Board of Education, makes provisions in the budget for the school personnel, and provides buildings, equipment, and maintenance. School principals and the supervisors are administrators in that they assist in curriculum improvement, making teacher assignments and time allotments, and in making recommendations for purchases of new equipment; but the final approval and implementing of the plans and recommendations rest with the superintendent and the Board of Education. The Board of Education, in turn, relies greatly upon the decisions of the superintendent. In turn, the superintendent must depend upon the supervisor and the principal to keep the program in operation.

In placing new emphasis upon the teaching of science, it is extremely important that consideration should be given to time allotment for science teachers, when at all possible. It is highly desirable for the high school science teacher to have a reasonable amount of time allotted from teaching for planning and arranging laboratory equipment. The provision of student help for clerical work and the handling of laboratory equipment, in many instances, can help to alleviate the time consuming duties of the teacher. It seems highly probable that in the near future a laboratory assistant will be employed to aid the science teacher in many of the details that is associated with a good science program. It is also highly desirable that science teachers should be allowed time to attend science conferences as part of their in-service training.

In case the school system does not have a science supervisor, then it becomes the duty of the superintendent and/or principal to know what goes on in the science classroom. Following a planned course outline, not necessarily day by day, but as a course content and sequence, is important on the part of the classroom teachers throughout all twelve grades. It is the responsibility of the administrators to see that the fullest possible use is being made of the facilities and equipment at hand.

The important role that the principal exercises in initiating a good science program cannot be stressed too much. No matter how many good facilities and equipment are provided by the superintendent and the Board of Education, the principal is responsible for a workable and functionable science program within his school; however, the teacher in the final analysis, is the person upon which a good science program rests.

II

ACTION FOR A SCIENCE PROGRAM UNDER THE NATIONAL DEFENSE EDUCATION ACT

The NDEA ACT was passed by Congress and was signed by President Eisenhower, September 2, 1958. Because of this act the science teachers along with the elementary teachers have before them one of the greatest challenges and opportunities ever offered teachers in the history of science education. One of the big excuses for not having a good science program has always been the lack of equipment, but this is no longer true. The great opportunities of the moment can only be realized if we all show initiative and vigor in selecting wisely and purchasing, and above all, using these tools of instruction which is made available by NDEA. This vast expenditure can only be justified when the classroom teachers makes the fullest use of the material purchased. This job will require the full cooperation of state and local administrators to help formulate a place of action for every classroom in the state; however, the best program and the best facilities are to no avail in absent of a dynamic and creative teacher.

II-1.

PROCEDURE TO BE EMPLOYED IN QUALIFYING FOR FEDERAL AID UNDER TITLE III, N.D.E.A.

Title III of The National Defense Education Act provides for a 50% reimbursement for expenditures for approved projects to procure equipment, materials and minor remodeling to provide improvement in instruction in science courses for all twelve grades.

A district initiates participation in the projects under the Act by writing an overall district plan for the three subject areas covered. The plan is carried out by one or more projects. Each project is activated by submitting a project application setting forth the objectives and the equipment to be procured, together with plans and specifications for any remodeling required to utilize the equipment. Upon approval of the project by the State Department, the district is authorized to place orders or let contracts.

Prior approval on all projects is required, and any expenditures made without this approval cannot be reimbursed.

District plans and project applications should be preceded by careful planning involving the teachers who are to use the equipment. Lists of equipment and materials such as reference books are available as source materials, but lists for individual projects compiled from these lists must have prior approval before purchase.

Lists are open ended, and items not on the department lists may be listed for approval.

Approximately two and one half million dollars was expended by Kentucky school districts for equipment in fiscal 1960, over 75% of the money going for science equipment.

Project applications must come from the office of the District Superintendent. All orders for equipment must come from the Superintendent's office, and all equipment must be billed to the local board of education. All invoices must be paid by the local boards of education, and complete records as required by the State Department must be kept in the office of the local board of education.

After having paid for the equipment, the local board of education may submit a claim for 50% of the cost of the approved equipment.

All correspondence regarding project applications should be addressed to the Coordinator of the National Defense Education Act, State Department of Education.

III

RECOMMENDATIONS PERTAINING TO THE SCIENCE CURRICULUM FOR THE ELEMENTARY AND SECONDARY SCHOOLS

1. There should be a recognized program of science instruction in each elementary grade, one through eight, in all public schools of Kentucky.

2. That science material in the first, second, and third grades may be integrated with other material in the daily program. However, the pupil should be aware of the fact that they are dealing with problems pertaining to science and that they are working toward developing a scientific understanding.

3. The science program in the fourth, fifth, sixth, seventh and eighth grades should have designated periods set aside during the day for the study of science, and as far as possible, laboratory experiences should be of an individual nature, or a carefully planned unit in science may be correlated with social subjects.

4. It is recommended that when the above continuity is followed through with a quality program, an introductory course to chemistry-physics or a ninth grade physical science course be offered to science talented students. However, it should be noted that the State Course of Study, August, 1959, lists introduction to chemistry-physics in the tenth grade and advanced physical science in the eleventh and twelfth grades. This ninth grade science offering should not be for the purpose of replacing general science nor advanced physical science.

   Note: In order to offer either of these courses in the ninth grade, permission must be granted by the Bureau of Instruction since it is not listed for the ninth grade in the present State Course of Study, August, 1958.

5. That all high school science courses conform to the regulations set forth in the present State Course of Study, and that all courses in science include adequate facilities and adequate time for individualized laboratory experiences.

IV

NEW TRENDS IN SCIENCE INSTRUCTION

*Science curriculums are receiving more attention now than it has in many decades. This is a basic re-thinking of the functions of science instruction at all levels and of the contributions which study in this field can make. Science instruction is changing, and there are many trends which seems apparent. Several of these trends have implications for the kinds of science facilities and equipment which schools provide. Some trends which should be kept in mind by schools when attempting to improve the science curriculum include:

1. A trend away from an emphasis on verification, formal type of demonstrations, individual laboratory exercises and toward an emphasis upon the development of understanding of principles by means of problem solving and related procedures carried on by pupils under the directions of the teacher.
2. A trend away from the use of applied technology as a theme for science courses and toward an emphasis on basic understanding which result in applications of scientific principles in a way which leads to improved technology.
3. A trend re-emphasizing the importance and necessity of pupil experimentation using controlled experimentation and testing of hypothesis in problem-solving situations.
4. A trend toward laboratory experiences which run over a much longer time, perhaps, several class periods or even weeks to bring to completion, and which may require equipment setups for the entire time.
5. A trend toward more adequate recognition of science instruction as a necessary component for all liberally educated people whether college bound or not.
6. A trend toward diversified science instruction as far as the variety of different experimental approaches is concerned, and in which different students seek solutions to different problems.
7. A trend toward the increased use of science clubs, science fairs, science congresses, and other supplemental devices to encourage and challenge academically able students, and to

*Report of an association conference on NDEA, Act 1958, National Science Teachers Association.

provide opportunities for all interested pupils to perform experiments and carry on projects in exploratory activities which may not be possible in the regularly scheduled periods.

8. A trend from rigid and static science facilities toward increased flexibility in design of such facilities so room sizes may be varied and work surfaces, services, storage spaces, and teaching aids may be changed in use or location to meet the peculiar needs of learning activities related to a developmental program.

9. A trend toward the increased use of audio-visual aids by individuals or small groups of pupils.

10. A trend toward the introduction of new units of study in the high school curriculum such as wave mechanics, nuclear energy, radioactives, isotopes, antibiotics, nutrition, and radiation biology, which will require more over-all space and in addition, more small specialized areas, some of which may be remote from the main science room.

11. A trend toward homogeneous grouping of pupils, especially for basic science courses. This enables academically talented pupils to be identified at an early age so that they may be stimulated and encouraged to progress at their own rate and to reach the fullest possible academic development. The teachers assigned to the more talented groups are usually those with good backgrounds in science who can challenge and lead pupils to perform experiments and do projects not ordinarily attempted in classes with lower interest ability ranges.

V

TEACHING ELEMENTARY SCIENCE

First of all, the teacher must have confidence, initiative, and must be willing to work. Teaching science in the elementary school is more widely accepted now than ever before; therefore, those who have a part in planning the curriculum are giving more attention to science. More thought is given to facilities and equipment when schools are constructed or remodeled. More attention is focused upon the teacher's program in elementary science by the administrators, patrons, and pupils. Science is everywhere children go and they must be taught how to live with it.

Science helps children find answers to questions about their environment; however, when science is properly taught it can do much more. It can build scientific attitudes, sharpen the ability of children to think critically, and help them to develop skills in problem solving.

No matter how anxious teachers are about teaching science, they are seeking direct and practical help in order to do a better job at this relatively new adventure in teaching. Teachers want to know more about the place of science in the lives of pupils in the elementary school program. Perhaps some of this can be described by attempting to answer: What Is Science? Where Is It? How Do Children Learn It?

What Is It?—Our eternal struggle to discover things of our universe.

1. It's not learning to identify twenty trees, twenty insects, or twenty flowers.
2. What is it then?
   (a) It is a study of the natural environment.
   (b) It comes from the areas of chemistry, physics, biology, and astronomy.
   (c) Questions such as:
      1. What makes the wind blow?
      2. What's in a cloud?
      3. What is a stone made of?
      4. What does a bell do when it rings?
      5. How can a seed grow into a tree?
      6. What makes a rainbow?
3. Grade children like to know the answers to such questions as above.
   (a) The answers to such questions is *Science*.
      1. The answers doesn't have to be technical.
      2. Full explanation is not what a ten year old needs.
      3. It is a foundation in the simple terms of How, The When, The Where, and The What of things.
      4. He does not need the technical terms, the formulas, and the detailed explanations.—That Comes Later.
      5. He needs his curiosity broadened, his enthusiasms encouraged.

Where Is It?

1. It is everywhere that elementary school children are.
   (a) It is in the air they breathe, water they drink, food they eat.

(b) It is the things they see on the *way to school.*
   1. How does electricity make a light burn? Where does it come from? How is it made? Why does Echo I stay in orbit?
   2. What makes the sky blue?

(c) In the *Home.*
   1. What makes the door bell ring?
   2. Why does Mama use bluing in the wash water to make the clothes white?

(d) In *School.*
   1. How can the fire extinguisher put out a fire?
   2. Why did we all have to be vaccinated?

2. Science is also a study of environment.

What Can It Do?

1. First of all, You don't want children to grow up unaware of the things that are going on in front of their eyes.
2. An educated person is one who knows something about the things they come in contact with each day.
3. It can equip the child with generalizations or meanings which they can use in interpreting problems in their environment.
4. It helps them grow in appreciation of things around them.
5. Help develop certain scientific ways of thinking as they work.
   (a) Things don't just happen; they happen because of natural causes—so don't be superstitious.
   (b) Help children to keep from jumping to conclusions.
      1. Be careful how children draw their *conclusions.*

WHAT ELEMENTARY TEACHERS FEAR IN SCIENCE TEACHING

"The Greatest Thing We Have To Fear Is Fear Itself"
Franklin D. Roosevelt

A great many elementary teachers are afraid of science. It is also true that the same teachers were afraid when they first learned to ride a bicycle, or when they learned to skate. In spite of the fear of science, the teacher uses it and is in contact with it daily, yet many are still frightened at the thought of having to teach it. Why?

Some teachers are afraid of not knowing. Many take the attitude that science is for the experts. The foundation of this fear probably is the lack of understanding that exists between the relationship of the purposes of elementary science and the materials, the facts and the concepts of science. Successful teaching of elementary science may be determined by how well children learn to observe and sense the environment in which they live, the attitude which they approach solutions to problems, and how well they use science as a tool for helping them solves problems with which they are confronted. Most of the elementary science textbooks are organized in such a way as to show a definite connection between the ways children grow and learn and the teaching of science in the elementary classroom. The teacher's edition of the textbooks in elementary science is arranged to give vivid descriptions of actual methods which a teacher can use to present a given subject matter to a specific grade.

Since one of the main purposes of teaching science is to help children observe their environment more carefully, we must set up situations which require children to observe. The stage can be set by asking questions such as: Why Does It Happen? What Would Happen If . . . .?

The ultimate goal in teaching elementary science is to develop observant, rational, and understanding children.

How Children Learn Science

1. By experimenting (one of the big aids to learning science)
2. By reading (Textbook is a guide only to the real thing—experience)
3. By observing
4. By taking trips
5. By visual aids[1]

    1. Experimenting: When performing experiments with children it is important to remember that (a) experiments should be kept simple, (b) the simplest material is often sufficient and almost always desirable, (c) pupils are capable of originating their own experiments and can often bring the necessary materials from home. They are much more enthusiastic about experimenting in this manner.
    Certain essentials should be considered when pupils perform experiments.

        1. Should be done in such a way as to make the pupil think. An experiment where the teacher tells the pupils everything leaves no food for growing minds.

[1]"Teaching Elementary Science", Dr. Paul E. Blackwood, U. S. Department of Health, Education, and Welfare. Bulletin 1948 No. 4.

2. Children should be conscious of the purpose for performing an experiment. The purpose may be written on the board or the experiment may be mimeographed, stating the purpose, materials to be used, operation of the experiment, and leave a blank for the conclusion, etc. Many experiments should originate from the pupils. Example: Children may observe the custodian scattering salt on the icy sidewalk and notice it causes ice to melt. The children want to know what causes the salt to clear the ice. Experiments may also arise from the textbooks.
3. Careful planning is essential to successful experimenting. Appropriate materials must be assembled (by the children, if possible). A plan of procedure must be set up, the plan should be accurately followed to insure reliable results.
4. Insofar as possible, children themselves should perform the experiment. Experiments involving fire or dangerous experiments should be performed by the teacher.
5. Many times the teacher may demonstrate an experiment for a definite purpose which may be helpful to the pupils.

2. Reading (Aids to Learning Science)
    1. Reading ranks high in the ways children learn science.
    2. It is only a part—children don't learn much real science by just reading. It must be experienced when possible.
       (a) Facts and fiction (b) Authenticity of materials
    3. Reading should be done with a definite purpose in mind.
    4. Reading may be a type of research for the pupil.

3. Observing
    1. Is an essential activity in all science teaching.
    2. The pupils should grow in their ability to observe more accurately and thoroughly.
    3. Feeling the texture of materials—it feels like salt. Feeling heat from a wire attached to a battery; seeing and hearing birds sing. (All are a part of learning science.)
    4. Some verbs that give keys to observing (a) touch, (b) watch, (c) smell, (d) weigh, (e) taste, (f) measure, (g) lift, (h) find, and many others.

5. The ability to observe accurately and to report observations correctly is a part of all activities of science.
6. Experimenting is at a loss in many cases without observation.

4. Taking Trips

Trips may be effective in:

(a) helping solve problems
(b) getting information
(c) for appreciation

In other words—to see science in industry in action, or observe nature at work

(d) Excursions should be made with definite purposes in mind
(e) Too many trips would not be good

5. Using Visual Aids
    1. Another way a pupil learns science is by seeing a picture either in motion or otherwise.
    2. Much depends upon how visual aids are used. Much planning is necessary. Just to show a film without planned purpose may not be even good entertainment.
    3. Select film suited to purpose. Prepare the class for the film. Follow up with discussion, questions, and answers.
    4. Whatever the visual aid is, let it be an activity for promoting understanding, interest, and appreciation.
    5. T-V, airborne program, is becoming a reality.
    6. Objects of scientific nature displayed within the classrooms.

Conditions Which Are Conducive To Learning Science

Children learn science in a variety of ways just as they learn anything else; however,

1. They learn it more readily when they are interested in it.
2. When they can see that it makes some difference to them.
3. When it is graphic.
4. When it involves some manipulation on their part.
5. When it is not too hard, but hard enough to make them think.
6. When it gives them some satisfaction in having found out something they wanted to know.

Some Safeguards Of Scientific Thinking

1. Realize things don't just happen; they happen because of natural causes.

2. Don't be superstitious.
3. Be open-minded toward opinions of others.
4. Hold your conclusions until you are sure.
5. Look to reliable sources for evidence.
6. Be willing to change your mind if you discover you are wrong.
7. Be curious about things and don't be satisfied with a vague explanation.

Things To Remember When Teaching Science To Children

1. Children are by nature curious, but there's a world of things that they know nothing about; therefore, can't be curious about those things. They need help.
2. Many life-long interests may be learned early in a child's school experience. Many scientists say that their interest in science began when they were still very young.
3. Science helps children to grow in appreciation of things around them. This is a difficult problem for them.
4. How children come to appreciate things—a little lecture on the beauties of nature won't do it for most children. But let's try to *teach* them to see, to *look* closely, to *examine* carefully, and to *discover* by themselves what wonders there are in the world around them.

   Example: In a common grain of corn—life itself is stored, that which man himself has not duplicated. He has learned what raw materials are used. He has learned in what conditions the life of a corn plant will start and grow. He can analyze the process, maybe to the last molecule, but he, himself, cannot duplicate the process or make a grain of corn; without this process life itself could not exist. In other words —as a child learns the truth, his appreciation grows. You, as a teacher, must decide what it is you hope to accomplish by teaching science, keep it in mind, keep checking to see that you are staying on the right track and keep evaluating to find out how closely you are coming to your goal. And, above all, let these purposes be those of the pupils as nearly as possible and let the pupils help with the plans for accomplishing your objectives.

Teachers' Tools For Teaching Science

1. Textbook—to use as a guide
2. Science—*Manual* for laboratory experiments

3. Good teacher's guide on teaching science
4. Equipment—either purchased or made from simple things from home or school. (Don't make science too complicated. Have confidence in yourself and work along with your pupils Keep the records and things you make for next year.)

How Children Solve Problems In Science

1. Identify problems by questions, etc.
2. State hypothesis
   a. by hunches
   b. by imagining
   c. maybe, etc.
3. Seek information
   a. from people
   b. from books
   c. from films
   d. by experimenting
   e. from experts
   f. from t-v, etc.
4. Assembling Information
   a. answers to questions
   b. what we know now
   c. concepts
   d. conclusion
5. Application
   a. use to me
   b. use to other people
6. Things for Future Study
   a. Never let the experiments fully satisfy the pupil's curiosity, leave a desire for further knowledge.

VI

WORKSHOP TYPE TRAINING FOR ELEMENTARY SCIENCE TEACHERS

Quite a lot has been said and done to help the elementary teacher do a better job of teaching science. However, the majority of the teachers indicate that they still need more training, especially in the workshop type, whereby they can actually take part in demonstrations and in assembling simple equipment for experiments.

The elementary teachers who are now teaching, in most instances, did not have enough science in high school or college to do the job that is now required of them. A united effort must be put forth to help the person who is so vital to the child, the teacher. Science is a thing we have, we must live with it, and we must know how to teach it effectively. The teacher is the one who needs help and is the one who must get help before we can expect much improvement in our science program in the elementary schools. Teachers, as well as students, learn most effectively when they become active participants in the learning situation. Teachers who need help are helped most when they can see an effective science program in action, rather than just being told what it is like. The workshop methods of training can be presented to the teachers while they are in service. (1) one of the quickest and most practical way to give immediate help to the teacher is to have a two or three day in-service workshop. (2) Also, a course of this nature offered by colleges on Saturday or after school hours. (3) Workshop type summer school courses. (4) Such courses offered to regular college students will help to better prepare the future teacher.

In order for the two or three day workshop to be most effective, careful planning on the part of the one who will conduct the workshop is a *must*. Equipment must be on hand for use of both the instructors and teacher, in order that several phases of fundamental science could be demonstrated in a short time.

The major portion of an elementary science workshop should be devoted to the practical laboratory type work in which the teacher can take part in constucting, and devising simple laboratory equipment from inexpensive material or from equipment purchased through the National Defense Education Act Program. This type of work should stimulate the teacher to observe and to experiment on the level of the pupils she will teach.

The one who is to guide the work should be well prepared in advance. Several dozen devices and experiments could be prepared to cover the various fields of science which will meet the needs. Experiment sheets could also be prepared for each experiment, giving such data as the name of the experiments, the purpose, the material needed, the method, the drawing of apparatus or material use, and the conclusion.

This type of workshop could be conducted on the fifth or sixth grade level, and the teacher could later alter the grade level to meet the need of the pupils being taught.

Anyone who had prepared these smiple experiments in advance could perform them very rapidly and the teachers could complete the experiment sheets on each experiment as it was performed. These sheets could be kept as future guides for the teacher for her use in her classroom.

When time would permit, the teacher could demonstrate to the group her technique on how to present an experiment to an elementary science class.

Many things could be gained by the teacher in this type of workshop. It would assimilate practical on the-job situations, and help promote self confidence.

Every child is by nature an experimenter. Once the teacher gets started on an effective science program, she can quickly motivate her pupils effectively because they are curious about why and how things happen and want to try out their own ideas. Children are ready to learn science when we are prepared to teach them.

VII

APPROPRIATE EXPERIENCES IN SCIENCE–GRADES ONE THROUGH EIGHT

The science experiences that we plan and provide for children should be based on the purposes of science in the elementary school. We should look to these objectives to guide us in determining what science principles or concepts are essential to children in helping them to solve their problems and decisions about appropriate experiences for children at different levels of maturity, it is of the utmost importance that we keep in mind how children learn and grow.

In selecting appropriate experiences for children, a balanced program should be planned that will give children many opportunities to become acquainted with the various broad areas of science. During their journey through the elementary school, children need opportunity to acquire some understanding of electricity, weather, plants, animals, the universe, energy, and matter. Sometimes the tendency is to put more emphasis and time on nature study, avoiding such topics as machines, electricity, and molecular structure.

It may be worth-while to look at some of the many kinds of activities that children and teachers might engage in during units of experience such as nature walks, field study trips, growing plants, caring for pets, experimenting, demonstrating, observing, dramatizing, writing, reporting, discussing, sharing, creating, constructing, listening, making tape recordings, and viewing films. Many other activities could be added, but the puropse of enumerating these varied activities is to bring attention to the fact that science is not limited to reading, experimenting, and demonstrating.

The kind of science that is envisioned here is replete with rich activities that contribute much to learning through participation. This makes science alive, stimulating, and interesting to children. Some might feel that in a situation of this kind the school might be overemphasizing certain activities and that reading and other skills may therefore be pushed out of the curriculum. On the contrary, a dynamic program calls for more reading—reading that is purposeful and meaningful to children.

The designation of general sections of science study in the elementary school will assist the curriculum builder in planning a program which will include both biological and physical sciences. Although areas of science study in the elementary school normally interrelate and overlap, a list of the areas is useful for reference and for checking balance in the science curriculum. The following list includes topics particularly appropriate for development in the elementary school curriculum:

Animals
Necessities for life
Life cycles
Structures and functions
Relationships to plants

Living Things
Distribution
Adaptation
Utilization by man

Human Beings
Structure
Heredity
Health

Plants
Necessities for life
Life cycles
Structures and functions
Relationships to animals
Distribution
Adaptation
Utilization by man
Conservation

The Earth
Records of the past
Ancient plants and animals
Structural changes
Atmosphere, weather, and climate
  Composition and properties
  Relationships to living things
Water
  Composition and forms
  Conservation

Structure of the earth today
Use of the earth's resources by man

The Universe
Our solar system
Sun
Planets
Moon
Earth
  Tides
  Seasons
Other heavenly bodies
Stars
Galaxies

Space
Characteristics
Exploration and scientific knowledge

Matter and Energy

Structure of matter
Molecules
Atoms
Forms of matter
Solids, liquids, and gases
Elements, compounds, and mixtures
Electricity
Gravity
Heat
Light
Sound
Man's use of matter and energy
Characteristics and uses of energy
Sources of energy
Relationships of matter and energy
Magnetism
Machines and power
Early machines
Simple machines
Power and man's progress
Advantages
Responsibilities

The foregoing topics are selected and arranged to give assistance in curriculum building. Apparent inconsistencies, such as listing human beings, although other kinds of animals are not listed and listing "the earth" as a major area of study and also as a subordinate topic under the heading, "the universe", emphasize the interrelatedness of science topics. The necessities of life for animals cannot be studied without attention to light, water, food, and air. Understanding the atmosphere, weather, and climate, incorporates knowledge of the sun, water, heat, and movements of the earth. Similar outlines of science topics are available in several publications on science for the elementary school.

All areas of science—living things, the earth, the universe, and matter and energy—should be incorporated in the science curriculum at all grade levels of the elementary school. Development of specific topics and the activities in which the children engage may vary from classroom to classroom at the same grade level. Community resources, locale, the availability of books and materials, the science background of the teacher, and previous science knowledge of the pupils will all affect the selection of topics. Other subjects of the elementary school curriculum will also suggest appropriate science topics.

A list of generalizations for science curriculum building provides a framework for planning daily lessons. The teacher with such a list sees relationships among the areas of science, considers topics that lend themselves to interrelated activities and learning, and begins to consider the contributions that the classroom, community, environment, and available materials and resources may make to the learning situation.

Concepts And Generalizations In Science

The following concepts and generalization in each category are presented according to the grade level at which they may be used successfully to provide pupils with science experiences that will be both purposeful and meaningful.

Living Things:

Primary Grades

Most living things are either plants or animals. There are many kinds of animals. Animals vary in size, shape, covering, and habitat. Animals vary in various environments. Animals need food, water, and air. There are many kinds of animal homes. Animals are alike in many ways. There are different types of animals. Animals get their food in different ways. Animals differ in the kind of food they eat.

Some animals stay in one place most of their lives. The shape and size of an animal may help it to survive. Animals grow and change. Animals change with the seasons. Human beings grow and change. Adaptations help an animal to be suited to a particular place in the environment. There are many kinds of plants. Plants vary in size and shape. There are different types of plants. Most plants need water and sunlight. Most plants make and store food. Plants can grow in soil or water. Plants grow in many places. Plants carry on processes of life. Plants change as they grow. Many plants change with the seasons. Some plants live longer than others. Dead and decaying plant material improves the soil. Plants have different methods of producing new plants. Most plants should be left to grow outdoors. People care for some animals and plants. We use plants in many different ways. Animals and plants are important to man.

Intermediate Grades

Animals are related to their physical environment. Adaptation of animals to their physical environment may take a long time. Animals vary in their adaptation to seasonal change. Animals vary in structure. Animals may be divided into groups by structure and function. Animals live through difficult environmental periods in a variety of ways. There are many theories about the causes of migration. Animals change in various ways as they grow. New varieties of animals and plants can be produced as a result of selective breeding. Some animals are useful to man; others are harmful. Some insects live in a complex social structure. Breathing is a process that provides some animals with oxygen and removes carbon dioxide from their systems. Digestion is a process for making food material usable in animals' bodies. Some diseases are caused by poor diet. Movements of many animals are produced by muscles. Man is an animal able to think and plan. There are ways to help human beings maintain health. Bodies of living travels from clouds to earth and back to clouds. Water comes out of the air as rain, fog, snow, sleet, or hail. Water is used for many purposes. Water is abundant in some places, scarce in others. Water is stored in different ways. Water is brought into buildings through pipes. Weather affects all living things. There are many kinds of weather. The changes of seasons affect the water supply for living things. The temperature changes from time to time and from place to place. Seasons are not the same everywhere. Changes in the weather can be measured and recorded.

Intermediate Grades

Soil contains several materials. Many kinds of animals of long ago no longer live on the earth. Rocks were formed by forces that have been at work for a long time and are still at work. Ancient plants and animals left traces of their life upon the earth. Many things about life on the earth at an earlier date may be ascertained by a study of rocks. We use rocks and minerals in many ways. There are three basic kinds of rocks. Changes in geological formations of the earth are occurring constantly. Topsoil is a long time in the making. Topsoil is the part of the earth in which plants grow. Topsoil contains mineral elements. About three-fourths of the earth's surface is covered with water, either salt or fresh. The waters of the earth contain dissolved minerals. Watersheds help to form natural regions for communities. The amount of water falling on a community affects the kinds of plant and animals living in the community. Plants retard the flow of water so that the water soaks into the soil. We need much water to grow our food and run our factories. Man can make changes in a community. Our best sources of water are rain and snow. Water cycles are occurring continually. Water has a great deal to do with changes in the earth's surface. The building of dams to hold back water increases the usefulness of the water to man. Energy comes from moving water. Underground reservoirs and surface drainage furnish our water supply. Water disposal systems are needed in communities. Air exerts pressure. Air expands when it is warmed. Wind is moving air. Weather conditions over a long period of time make up the climate of a region. Weather conditions at any one place are part of a world-wide system. Our present-day world of machines and power depends on natural resources. The rotation of the earth on its axis in relation to the sun causes day and night. The North Pole of the earth always points in the direction of the North Star. The earth travels once around the sun in about 365 days. The inside of the earth is hot. The sun is always shining on some part of the earth.

Light energy striking the surface of the earth causes seasonal change. Light energy from the sun produces different amounts of heat energy in different parts of the earth. Seasons have characteristic weather conditions.

Upper Grades

The soil is one of man's important resources. Soil formation is going on all the time. A great part of soil is derived from rocks. Both living and dead plants and animals aid soil formation. As a result of decay, materials which came from the soil are returned to the soil. Some places on the earth are being built up while others are being worn down. Weathering of the earth helps to form soil. By studying rocks, geologists learn about the earth's past. Scientists do not agree on how or when the earth was formed. Most of our metals come from minerals. Knowledge of soil, climate, and living things enables us to use land more wisely. Petroleum was formed from ancient plants and animals. Rocks are composed of minerals. Man uses the rocks of the earth in many ways. Some of our fuels and metals are from nonrenewable resources. Many minor changes taking place over a long period of time may affect the earth as much as one major change. Mountains are formed and changed by several forces of nature. Ocean tides occur every several hours. The ocean is a source of supply of energy and material. Water is a chemical compound. Water is essential for the human body. The physical behavior of water accounts for some of its usefulness to man. Water is an important factor in industry. Waterways still provide the basis for most world-wide transportation. Keeping the water supply safe and pure is one of man's greatest accomplishments. Our measurement of time is based on the movements of the earth. The earth may be considered large or small, depending upon what it is compared with. As the sun travels through space, the earth and all the other members of the solar system travel in relation to it. The atmosphere is made up of molecules. The atmosphere protects the earth in many ways. There is electricity in the atmosphere. Relative humidity is an important factor in measuring weather characteristics. Layers of atmosphere have different characteristics at different altitudes. Characteristics of the atmosphere vary according to surface conditions on the earth. Many devices, including radar and infrared light, are used in the study of weather phenomena. Man's study and exploration help him to understand and predict weather. Energy from the sun is the driving force responsible for our weather. Weather is a world-wide phenomenon—an important determining factor in world trade and world affairs. The governments of nations are concerned with matters pertaining to the study of weather. Scientists use a variety of methods to learn about places they cannot see. There is still much we do not know about the planet on which we live. Scientists are constantly trying to learn more about the earth.

Natural resources are the basis for the maintenance of any people's standard of living.

The Universe:

Primary Grades

The sky changes during both the night and day. The sun warms the earth and people and things on the earth. The seasons follow a pattern of spring, summer, fall, winter. Nearly all the light we have on earth comes from the sun. Sunlight contains all colors. The sun is far away. The sun looks small but it is very large. The sun shines all the time. The sun is made of hot, glowing gases. Shadows are made when light is obstructed by objects. Light and heat from the sun are necessary to life on the earth. The sun and earth are related but they are very different. Light from the sun reaches the moon. The moon is nearer the earth than any other natural object in the sky. The moon is smaller than the earth or sun. The moon seems to change its shape. Moonlight is light from the sun reflected by the moon. The moon and the earth are alike in some ways and different in some ways. Stars vary in size, brightness, and distance from the earth. Outer space is different from the earth's atmosphere.

Intermediate Grades

Distances in the sky are vast. Measurement of space in the universe is computed in light years. The sun, planets, and related heavenly bodies make up a group called the solar system. Gravity is a vital force in the universe. The planets of the solar system revolve around the sun. The sun is one of billions of stars in the sky. The moon appears to change in size and shape. The planets of our solar system have some similar and some dissimilar characteristics. Instruments have been developed which help us obtain information about the heavenly bodies. Vast space, much material, and many celestial bodies exist beyond our solar system. The light of the Milky Way comes from millions of stars. Each star in the Milky Way is far away from its nearest neighbor. Stars in a constellation appear to be near each other. Most of the stars we can see with the naked eye are part of the Milky Way Galaxy. The whole Milky Way Galaxy is moving through space. There are millions of other galaxies besides our own.

All the groups of galaxies make up the universe. Distant objects in the sky are viewed across great spans of space and time.

Upper Grades

All the planets revolve around the sun. Gravity holds the planets in their orbits. All the planets shine by reflected light. The planets differ from each other in several ways. The period of orbit of a planet is related to its distance from the sun. Astronomers can predict the phases of the moon and eclipses of the sun and moon. Astronomers use mathematics and various instruments to study the universe. Several theories have been advanced about origin of the solar system. The characteristics of space, of living things, and of physical laws have to be considered in space travel. The organization of the solar system resembles the organization of an atom.

Matter and Energy:

Primary Grades

Heat travels from one place to another. Heating and cooling produce changes in materials. Changes going on about us include evaporation, rusting, burning, decaying, and dissolving. Magnets have a special effect on pieces of iron or steel. Magnets can be used to indicate direction on the earth. Magnets have characteristics used to make motors run. Iron or steel objects which are not magnets can be magnetized by contact with a magnet. Energy is the ability to do work. Energy can move things. The energy of electricity can be used to do useful work. Many machines run by electricity. Energy can be stored in a dry cell. Electricity needs a continuous pathway to travel. A break in an electric circuit stops the flow of electricity at that point. Energy is useful in different forms, including wind, water, electricity, and gasoline. We hear many different kinds of sounds. Sound is produced by vibration. Sound travels through the air in all directions. Sound can be reflected. Under ordinary conditions, light travels in a straight line. White light is composed of all colors. Many tasks are made easier by machinery. Wheels are used on many machines. Friction exists when two objects slide or roll against one another.

Intermediate Grades

The earth and all the things on it are made of chemicals. Elements are basic chemicals of which all other materials are made. Elements are composed of atoms. Man has been able to make new elements. Oxygen, carbon, and hydrogen are common and important chemicals. Chemical mixing does not change the original chemicals. Chemical mixtures can be taken apart. Elements may combine to form compound. Chemicals put together to form a compound make an entirely new substance. Molecules are small particles of a substance. Heat and light cause certain chemical changes. Water and carbon dioxide are important chemicals in any community. Most animals cannot live without a supply of oxygen. Oxygen is necessary to burn fuel. Many materials which undergo chemical changes are formed into new materials. Change of any kind involves energy. There are many different kinds of sources of energy. Our biggest source of energy is the sun. The energy of the sun is produced from atoms. Light energy is changed by plants to chemical energy. Energy is released when fuel is used. Many fuels were formed in the earth by ancient plants and animals. There are vast quantities of energy inside the atom. A problem in the use of atomic energy is to release the energy so that it can be used as needed. Uranium is one fuel being used to release atomic energy. When a metal receives enough heat energy, some of the energy is changed into light. Light is a form of energy. Light travels through the air or through space. Light may change direction when it strikes an object. Light may be produced by the burning of some material. The color of objects depends upon the light that strikes them. Light is reflected from objects. Electricity is a form of energy. Electrical energy may be used for many purposes. Electricity can be used to produce sound, heat, and light. Electrical energy is produced by movement of electrons. The chemical energy in a dry cell changes into electrical energy as it is used. Electrical energy is often into mechanical energy through the use of a motor. A current of electrical energy can produce the same effect as a magnet. Electromagnets are made by using electricity. Electromagnets are used in many ways. Lodestone is a natural magnet. The earth has a magnetic field in which we all live. The sun affects the earth's magnetism. The use of electricity is a recent and significant accomplishment. Prior to about 1800, mechanical energy was available only from the use of animals, wind, and water. Wind is produced mainly by gravity and the energy of the sun. Man is still learning how to use energy of moving water and wind. Machines enable man to use energy more effectively. Machines are mechanical devices which help man to do his work more effectively. A machine makes work less difficult, but uses the same amount of energy to do the operation. There are many sources of power for making machines move. Jet propulsion utilizes the opposite forces of action and reaction. Our daily living is affected in many ways by the invention of the wheel and axle. Basic machines are combined to make complex machines. Sound travels through gases, liquids, and solids. Sound travels more easily through some substances than others. The ear is the organ through which we hear sound. Sound has several characteristics. Music is a special form of sound. Heating and cooling can cause materials to change their physical state. The first real engine was the steam engine. Gravity is a vital force throughout the universe. Moving air exerts pressure in a manner different from that exerted by motionless air. Air offers resistance to objects moving through it.

Upper Grades

Scientists are continually learning more about the composition of materials. Early man changed materials very little. All materials are made of one or more of the elements. Chemists use symbols to designate elements. Compounds may be formed from the elements, from elements and compounds or from compounds. The amount of one material that will dissolve in another is limited. Men have become builders of molecules. Men have developed many kinds of new materials. Many drugs have been made in the laboratory. Alloys are mixtures of two or more metals or of a nonmetal and a metal. When fuel burns, molecular action takes place. Engine fuel combustion may be internal or external. Carbon dioxide and carbon monoxide are byproducts of burning. The heat value of fuels may be measured. Heat travels from a place of higher temperature to one of lower temperature. Some substances are better conductors of heat than others. Some objects radiate light; others reflect light. The human eye is an organ that is sensitive to light. There are many different wave lengths of light. Sound waves can be used to serve many purposes. Control of sound waves increase their usefulness. The energy of animals comes from the sun by way of the foods they eat. Energy from the sun is changed by green plants into chemical energy. The sun's energy is responsible for our weather. Ways of using energy direct from the sun are being developed. Atoms are the most recently discovered source of energy. Energy can be obtained from the nuclei of atoms by fusion and by fission. Progress in the use of energy has been possible partly because of man's ability to use tools and build machines. Progress is being made in the development of the uses of atomic energy. Many energy changes occur in nature without man's influence. An important characteristic of a simple machine is its mechanical advantage. The work of a machine can be measured. Power dams and gasoline, diesel, steam, and jet engines change energy from one form to another. Atomic engines differ from other types of engines chiefly in the kind of fuel used. There are lines of force around an electromagnet similar to those around a permanent magnet. Many kinds of radiant energy are within the group of electromagnetic waves, including radio and television waves, radiant heat, infrared light, visible light, ultraviolet light, X-rays, and cosmic rays. Forms of radiant energy seem to travel in a wave motion. Electricity can be produced in several ways. Electrons are made to flow when the lines of force around an electromagnet are cut by a coil of wire. A generator converts heat or some other forms of energy into electrical energy. Electrical energy can be transformed into light energy and heat energy. Forces work in pairs; equal and opposite forces are found everywhere in nature. On the earth, centrifugal force and gravity oppose each other.

THE PURPOSES OF SCIENCE IN THE ELEMENTARY SCHOOL

Most children enter elementary school with a consuming curiosity about the world in which they live. They want to know the what, how, and why of their environment. When children seek such information regarding their environment they may be behaving like scientists. The test as to whether they are really behaving like scientists depends upon the processes they use in their quest.

Science is the relentless search for truth about the universe. In the word "truth", we have the concept of verifiable knowledge—knowledge which, checked by others using the best available methods of observation, appears to be valid. In searching, scientists use many processes on inquiry—investigating, probing, experimenting, checking, exploring, thinking, reasoning, and analyzing. In using these processes, scientists endeavor to describe, even more precisely, various phenomena in the world. They seek also to explain these phenomena and to organize their understandings into conceptual schemes. The foregoing definition of science and the description of what scientists do gives us one basis upon which to develop the purposes of science education. The following proposed purposes seem consistent with our definition of science and with the goals of education in American democracy.

1. To provide children with experiences which help them to develop the skills of thinking, observing, analyzing, and investigating, in order to arrive at plausible explanations, solutions, or answers to their questions about the world in which they live.

2. To help children understand and organize their knowledge of science, including information, concepts, and generalizations that have been or can be verified by scientific methods.
3. To help children develop attitudes consistent with the methods and content of science such as open mindedness, critical thinking, withholding judgment until all the facts are known, and willingness to change an idea when new evidence is discovered.
4. To help children understand that discovery of knowledge continues—that there is more to be learned than is now known about the universe.
5. To help children in the application of scientific methods and knowledge to the solution of their own and group problems in all areas of living.
6. To help children appreciate the contribution of science to the progress of man.
7. To help children appreciate the scientific contributions of others through stories of the lives of great scientists who made and are making personal sacrifices in the search for truth.
8. To help children gain respect for their bodies and for the family of men as they deepen their understanding of the wonders of human growth.
9. To help children develop a sense of responsibility for the wise application of science to the problems and circumstances of everyday life and to the modifications and control of environment for the improvement of human welfare.

[1] The material for Section VII has been adapted from "Looking Ahead in Science", California State Department of Education, 1960.

VIII

ORGANIZATION OF EQUIPMENT AND SUPPLIES—ELEMENTARY GRADES

A well organized plan is of utmost importance since time is a big factor to the elementary teacher. The materials to be used must be so arranged that they are readily available for use. No teacher has the time to spend ten or fifteen minutes every day locating materials to teach a science class.

The following hints may be helpful, especially for teachers in self-sustained classrooms where several teachers use the same equipment.

I. Equipment Arrangement

A. Have all equipment centrally located, preferably on the same floor level.

(a) Classify the equipment and place in boxes or trays which can be conveniently placed on shelves or in a storage cabinet.

(b) A suggested list of equipment and supplies that may be placed in each tray and labeled as follows:

1. *Atmosphere*

Balloons
Corks
Test Tubes
2 Flasks
Rubber Stoppers
Large Diameter Glass Tubes
Small Diameter Glass Tubes
Rubber Tubing
2 Tubing Clamps
Steel Wool
Lead Shot

2. *Air Pressure*

Metal Can
Lift Pump
Rubber Tubing
Glass Tumbler
Atmospheric Pressure Cups
Pipette
Mercury
Stopper with Hose Nipple

3. *Acids and Bases*

Red Litmus Paper
Blue Litmus Paper
Zinc
Vinegar
Lime Water
Splints
Sodium Hydroxide Solution
Sulfuric Acid
Hydrochloric Acid
Ammonium Hydroxide
Medicine Dropper
Test Tubes

4. *Bouyancy*

Cork
Sinkers
Tissue Paper
Piece of Lead Foil
Needles
Metal Disk
Pascal's Vase
Cartesian Diver
Cylinder
Piece of Rubber Sheet
Alcohol
Wood Blocks

5. *Compounds and Mixtures*

Stirring Rod
Horseshoe Magnet
Iron Filings
Powdered Sulfur
Sodium Chloride

6. *Cells, Plants—Structure and Germination*

Set Capillary Tubes
Ethyl Alcohol
Camine
Microscope Slides
Medicine Dropper
Tincture of Iodine
Dark Cardboard for Light Shield
Razor Blade
Magnifier

7. *Cells, Electric*

Student's Cell
Light Bulb (1½ Volt)
Light Socket
Knife Switch
Zinc Strips
Aluminum Strips
Insulated Wire
Small Beaker or Glass
Iron Strip
Copper Sulfate
Sulfuric Acid (Diluted)
Sodium Hydroxide (Diluted)
Sugar
Sandpaper
Lemon Juice
4 Flash Light Cells

8. *Color—Basic Principles of Light*

Prism
Screen or White Sheet of Paper
Knife Switch
Color Disks
Magnifying Glass
Candle
Silver Nitrate Solution
Small Electric Motor
Insulated Wire
2 Dry Cells
Curve Mirror
Set Palaroid Disk
Sodium Chloride

9. *Distillations and Solutions*

Funnel
Filter Paper
Distillation Apparatus
Spoon
Burette Clamps
Medicine Dropper
Stirring Rod
Glass Cylinder
Copper Sulfate
Rubber Tubing
Starch
Tincture of Iodine
Oil

10. *Expansion*

- Test Tube
- 3 ft. Plain Wire
- Bell and Ring
- Compound Bar
- Piece of Glass Tubing
- Rubber Stopper—1 Hole
- Weight
- Cork
- Sodium Chloride
- Carmine

11. *Energy, Friction, Inertia*

- Ball and Cord Inertia Apparatus
- Large Mouth Bottle, Card and a Marble
- 2 Double Rods— 8″ long ½″ dia.
- Cork
- Smooth Wood Block
- Sulfuric Acid
- Ammonium Chlorlide
- Weights
- Cord (String)
- Spring Balance

12. *Electromagnetism and Simple Circuits*

- 2 Dry Cells
- Small Electric Motor
- Insulated Wire
- Knife Switch
- Soft-Iron Rod
- Card
- Brass Rod
- Plastic Rod
- Fiber Tube
- Glass Rod
- Wooden Rod
- Iron Filings
- Carpet Tacks

13. *Electricity—Static*

- Cord
- Plastic Friction Rod
- Silk Pad
- Flannel Pad
- Electroscope
- Glass Friction Rod
- Hard Rubber Friction Rod
- Pith Balls
- Wire Stirrup

14. *Fire Extinguishers—Fuels and Burning*

- Splints
- Candle
- Wide Mouth Bottle
- Piece of Glass
- Piece of Sheet Iron
- Magnesium Ribbon
- Stopper
- Lime Water
- Soft Coal
- Sulfur
- Charcoal Lump
- Rubber Tubing
- Funnel

15. *Foods and Digestion*

- Medicine Dropper
- 3 Test Tubes
- Spoon
- Stirring Rod
- Iodine
- Fehling's Solution A and B
- Sulfuric Acid, Concentrated
- Bladder
- Sugar
- Dilute Hydorchloric Acid
- Pancreatin
- Copper Sulfate
- Starch
- Corn Syrup
- Nitric Acid, Dilute

16. *Heat Transfer*

- 2 Thermometers
- 2 Test Tubes
- Conductometer
- Lamp Chimney
- Erlenmeyer Flask
- Carmine Stopper
- Paraffin Glass Tube
- Touch Paper

17. *Heat and Temperature*

- Fahrenheit Thermometer
- Centigrade Thermometer
- Paraffin

18. *Living Things, Classification of*

- Magnifier
- Microscope (if available)
- Prepared Slides, such as:
  - Algae
  - Bacteria
  - Fern
  - Hydra
  - Hookworm
  - Plant Rust
  - Moss, etc.
- Preserved Materials, such as:
  - Clam
  - Starfish
  - Sponge
  - Squid
- Many Specimens can be collected by students.

19. *Magnets—Magnetic Field*

- Lodestone
- Soft Iron Rod
- Breaking Magnet
- 2 Bar Magnets
- Iron Filings
- Carpet Tacks
- Horseshoe Magnet
- Iron Washers
- Sheets of Paper
- Magnetic Compass
- Glass Plate

20. *Machines, Simple*

Spring Balance
2 Single Pulleys
1 Double Pulley
Demonstration Balance
3 Knife-Edge Clamps
1 Weight Car or Wagon
1 Incline Board
(Have Available)
Trip Balance
½ Meter Stick
Weights

21. *Oxygen and Hydrogen*

Test Tubes (Pyrex)
Test Tube Holder
Electrolysis Apparatus
Insulated Wire
Switch
Cork
Mercuric Oxide
Sulfuric Acid
Wood Splints
(Batteries, Hot Plate, Battery Jar, etc. should be available)

22. *Rocks and Minerals*

Test Tubes (Pyrex)
Stirring Rod
Charcoal Block
Glass Tube
1-Hole Rubber Stopper
Marble Chips
In Bottles:
- Gravel
- Sand
- Clay
- Charcoal Powder
- Hydrochloric Acid
- Selected Rock Specimens

23. *Sound*

Tuning Fork
Resonance Tube
Hook Collar (for Wire Tension)
Rubber Bands
Steel Wire—3 or 4 ft.
(Battery Jar available)

II. It should be noted that the above list of equipment is all small equipment and supplies. The larger, easy to locate, equipment may conveniently be located on shelves.

IX

THINGS THAT TEND TO CONSTITUTE A CREDITABLE COURSE IN HIGH SCHOOL SCIENCE

It is impossible to relate in a few paragraphs all the criteria that should be considered in a high school science course to be considered worthy of giving high school credit. However, a few of the things that should be considered as imperative are as follows:

I. Well organized program—planned by—(teachers, administrators, students, and laymen). The plan must be one under which the school can function and grow.

II. The plan must consider—

a. Qualified teachers.

b. Approvable facilities—classroom and laboratory or classroom laboratory combination and also, adequate instructional equipment and supplies.

c. General basic program for all high school students plus provisions for specialized science education for students of high ability and interest.

(It is no longer true that most educated people can get along quite well without understanding science.)

III. No high school course in science is worthy of the name—without the proper laboratory experiences which should accompany the course.

IV. Science courses should be organized and properly operated upon the basic of approximately 3/5 of the time devoted to class work and 2/5 of the time devoted to laboratory work. The laboratory work should be done by the students under the guidance of the science teacher or laboratory instructor. Experiments performed in the laboratory should be open-ended in the fact that students cannot anticipate the answers. They must pose question to nature, and then proceed toward the answer. They must make predictions and then verify or disapprove them. Examples of the above type of experiments have been compiled by the Manufacturing Chemists' Association, and are now published for use in high school chemistry.

V. It is no wonder that students shun science courses when so many times only a lecture course is offered. It is incredible to offer a science course and let experimentation play a minor role. Administrators *must* insist on adequate laboratory experimentation and at the same time recognize that this requires considerable preparation time, a flexible schedule, a preparation area, a reasonable budget, facilities and a limited size class.

VI. Supplementary Reference Materials Needed—

The textbook always takes a commending position. However, it should be noted that textbooks are produced to provide for an assumed national common denominator of the students interest and ability.[1]

a. Reference materials should always be available in every science classroom. The school library should provide a broad selection of reference materials. Excellent suggestions for science library reference materials may be obtained from:
   1. The AAAS Science Book List
   2. An Inexpensive Science Library
   3. The Science Book List for Children
   4. The Traveling High School Science Library List, etc.

X

ACHIEVING THE PROBLEM SOLVING OBJECTIVE*

Problem solving, or scientific thinking, is a widely accepted outcome of science teaching in schools over the country. In the past much attention has been given to this objective in science education literature and there appears to be an increasing interest in it at present.

Very little reliable evidence is available to indicate the extent to which the problem solving objective is provided for in day-to-day classroom activities. Still less evidence is available on the extent to which the objective is achieved with the young people who study science.

Among other difficulties in reaching the fullest attainment of the objective is the failure, on the part of many teachers, to recognize that

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[1]Joint Committee on Improvement of Science Teaching, Improving Science Programs in Illinois Schools. Urbana: University of Illinois, 1958, p. 51

*Ellsworth S. Obourn and Lloyd K. Johnson, Specialists for Science problem solving behavior is a complex ability made up of elements which can be identified. Some of these elements are quite simple manipulative skills but many more are of a highly intellectual character.

Regardless of the category in which these skills fall, it is very important to recognize that they are developed by recurrent practice just as any skill is developed. Thus, if a teacher wishes to develop some maniplative skill related to problem solving, such as learning how to locate information in a library, the skill must first be taught thoroughly and then practiced until achieved. In a similar way, if the teacher wishes to develop the ability to analyze problems, or interpret evidence, the skills must first be taught and then the teacher must provide classroom situations, day after day, where the pupil will have to use them. There is no easy way of teaching children to use the abilities of problem solving other than by setting classroom situations which call for their repetitive use.

Some authorities have characterized the steps in problem solving as a complete act of thought. This has led many teachers to believe that the act of problem-solving thinking, beginning with the recognition of a problem and ending with a conclusion, must always be practiced in its complete cycle. This is not necessarily true. Scientists rarely ever use the method in its complete cycle. In fact, they are more likely to use it in other ways.

For example, it is quite possible, in fact even desirable, to use the science lesson of a given day for practicing whatever elements of the total problem-solving pattern it may best be directed toward. In the development of a topic the teacher may plan to do a demonstration on a given day. This demonstration might provide material especially useful for practicing, among other things, the ability to interpret data. It should be used fully for this purpose and the teacher should see to it that all aspects of data interpretation afforded by the demonstration are carefully identified, clearly understood, and thoroughly practiced by the class.

On another day the teacher might fine that a laboratory exercise could provide opportunities for testing an hypothesis or evaluating assumptions. This experience should be used to yield whatever practice for these purposes it might possess. The important thing to remember is that almost every classroom situation can in some way contribute opportunities for pupils to practice certain elements of problem solving.

The teacher must be alert to recognize these opportunities and to make the fullest use of each one. The following provides an analysis of the attitudes of mind that accompany problem-solving behavior and also an analysis of each of the major elements in problem solving. Such an analysis is essential first to suggest guides for teachers in planning classroom situations that will call for the practice of essential skills and second, to provide a basis for developing tests to evaluate the degree to which the skills have been attained.

PROBLEM SOLVING BEHAVIORS*

I. Attitudes which can be developed through science teaching. The science program should develop the attitude which will modify the individual's behavior so that he:

   A. Looks for the natural cause of things that happen

      1. Does not believe in superstitions such as charms or signs of good or bad luck
      2. Believes that occurrences which seem strange and mysterious can always be explained by natural cause
      3. Believes that there is not necessarily a connection between two events just because they occur at the same time

   B. Is openminded toward work, opinions of others, and information related to his problem

      1. Believes that truth never changes, but that his ideas of what is true may change as he gains better understanding of the truth
      2. Bases his ideas upon the best evidence and not upon tradition alone
      3. Revises his opinions and conclusions in light of additional reliable information
      4. Listens to, observes, or reads evidence supporting ideas contrary to his personal opinions
      5. Accepts no conclusion as final or ultimate

   C. Bases opinions and conclusions on adequate evidence

      1. Is slow to accept as facts any that are not supported by convincing proof

*Dr. Darrell Barnard, Professor of Education and Head of the Department of Science Education, N.Y. University, and Dr. Ellsworth Obourn, U.S. Office of Education.

2. Bases his conclusions upon evidence obtained from a variety of dependable sources
3. Hunts for the most satisfactory explanation of observed phenomena that the evidence permits
4. Sticks to the facts and refrains from exaggeration
5. Does not permit his personal pride, bias, prejudice or ambition to pervert the truth
6. Does not make snap judgments or jump to conclusions

D. Evaluates techniques and procedures used, and information obtained
   1. Uses a planned procedure in solving his problems
   2. Uses the various techniques and procedures which may be applied in obtaining information
   3. Adapts the various techniques and procedures to the problem at hand
   4. Personally considers the information obtained and decides whether it relates to the problem
   5. Judges whether the information is sound, sensible, and complete enough to allow a conclusion to be made
   6. Selects the most recent, authoritative, and accurate information related to the problem
   7. Rejects inaccurate, unauthoritative information

E. Is curious concerning the things he observes
   1. Wants to know the "whys" "whats" and "hows" of observed phenomena
   2. Is not satisfied with vague answers to his questions

II. Problem solving abilities which can be developed through science teaching.

The science program should develop those abilities involved in problem solving which will modify the individual's behavior so that he:

A. Formulates significant problems
   1. Senses situations involving personal and social problems
   2. Recognizes specific problems in these situations
   3. Isolates the single major idea in the problem
   4. States the problem in question form

5. States the problem in definite and concise language
6. Identifies and states the limitations of problems

B. Analyzes Problems
1. Picks out the key words of a problem statement
2. Defines key words as a means of getting a better understanding of the problem

C. Obtains information regarding a problem from a variety of sources
1. Recalls past experiences which bear upon his problem
2. Isolates elements common in experience and problem
3. Locates source materials
    a. Uses the various parts of a book.
        (1) Uses key words in the problem statement for locating material in the index
        (2) Chooses proper sub-topics in the index
        (3) Uses alphabetized materials, cross references, the table of contents, the title page, the glossary, figures, pictures and diagrams, footnotes, topical heading, running headings, marginal headings, an appendix, a pronunciation list, and "see also" references
    b. Uses materials other than textbooks such as: encyclopedias, popularly written books, handbooks, dictionaries, magazines, newspapers, pamphlets, catalogues, bulletins, films, apparatus, guide letters, numbers, signs, marks in locating information, bibliographies.
    c. Uses library facilities such as: the card index, the Readers' Guide, and the services of the librarian.
4. Uses source materials
    a. Uses aids in comprehending material read.
        (1) Finds main ideas in a paragraph
        (2) Uses reading signals
        (3) Formulates statements from reading
        (4) Phrases topics from sentences
        (5) Skims for main ideas
        (6) Learns meanings of words and phrases from context

(7) Selects the printed material related to the problem
(8) Cross-checks a book concerning the same topic
(9) Recognizes both objective and opinionated evidence
(10) Determines the main topic over several paragraphs
(11) Takes notes
(12) Arranges ideas in an organized manner
(13) Makes outlines

b. Interprets graphic material.
(1) Obtains information from different kinds of graphic material
(2) Reads titles, column headings, legends, and data recorded
(3) Evaluates conclusions based upon the data recorded
(4) Formulates the main ideas presented

5. Uses experimental procedures appropriate to the problem

a. Devises experimental procedures appropriate to the problem.
(1) Selects the main factors in the experiment
(2) Identifies all the variables (Things that may change)
(3) Sets up controls for each variable

b. Carries out the details of the experiment.
(1) Identifies effects and determines causes
(2) Tests the effects of the experimental factors under varying conditions
(3) Performs the experiment for a sufficient length of time
(4) Accurately determines and records quantitative and qualitative data
(5) Develops a logical organization of recorded data
(6) Generalizes upon the basis of organized data

c. Manipulates the laboratory equipment needed in solving the problem.
(1) Select kinds of equipment or materials that will aid in solving the problem
(2) Manipulates equipment or material with an understanding of its function to the outcome of the experiment

(3) Recognizes that equipment is only a means to the end results

(4) Determines the relationship between observed actions or occurrences and the problem

(5) Appraises scales and divisions of scales on measuring devices

(6) Obtains correct values from measuring devices

(7) Recognizes capacities or limitations of equipment

(8) Returns equipment clean and in good condition

(9) Avoids hazards and consequent personal accidents

(10) Practices neatness and orderliness

(11) Avoids waste in the use of materials

(12) Exercises reasonable care of fragile or perishable equipment

6. Solves mathematical problems necessary in obtaining pertinent data

   a. Picks out the elements in a mathematical problem that can be used in its solution.

   b. Sees relationships between these elements.

   c. Uses essential formulae.

   d. Performs fundamental operations as addition, subtraction, multiplication and division.

   e. Uses the metric and English system of measurement.

   f. Understands the mathematical terms used in these problems; i.e., square, proportion, area, volume, etc.

7. Makes observation suitable for solving the problem

   a. Observes demonstrations.

      (1) Devises suitable demonstrations

      (2) Selects materials and equipment needed in the demonstration

      (3) Identifies the important ideas demonstrated

   b. Picks out the important ideas presented by pictures, slides, and motion pictures.

   c. Picks out the important ideas presented by models and exhibits.

   d. Uses the resources of the community for purposes of obtaining information pertinent to the problem.

(1) Locates conditions or situations in the community to observe

(2) Picks out the essential ideas from such observation

8. Uses talks and interviews as sources of information
   a. Selects individuals who can contribute to the solution of the problem.
   b. Makes suitable plans for the talk or interview.
   c. Appropriately contacts the person who is to talk.
   d. Selects the main ideas from the activity.
   e. Properly acknowledges the courtesy of the individual interviewed.

D. Organizes the data obtained
   1. Uses appropriate means for organizing data
      a. Constructs tables.
      b. Constructs graphs.
      c. Prepares summaries.
      d. Makes outlines.
      e. Constructs diagrams.
      f. Uses photographs.
      g. Uses suitable statistical procedures.

E. Interprets organized data
   1. Selects the important ideas related to the problem
   2. Identifies the different relationships which may exist between the important ideas
   3. States these relationships as generalizations which may serve as hypotheses

F. Tests the hypotheses
   1. Checks proposed conclusion with authority
   2. Devises experimental procedures suitable for testing the hypotheses
   3. Rechecks data for errors in interpretation
   4. Applies hypothesis to the problem to determine its adequacy

G. Formulates a conclusion
   1. Accepts the most tenable of the tested hypotheses
   2. Uses this hypothesis as a basis for generalizing in terms of similar problem situations

XI

Table I is a summary of the pupil enrollments in science as taken directly from the Principals' Annual High School Reports for October, 1957, and October, 1960. All public high schools, county, independent, and state enrolling pupils in grades 9-12 irrespective of organizational pattern are reported by county. The course offerings listed are those approved by the State Board of Education. A few courses offered by special approval that do not conform to this listing are included in the related areas.

In general, Kentucky high schools have followed the predominate national pattern of concentrating science in the ninth and tenth grades.

TABLE I

COURSE OFFERINGS AND PUPIL ENROLLMENT IN SCIENCE IN KENTUCKY PUBLIC SCHOOLS BY COUNTIES AS GEOGRAPHIC UNIT

1957-58
1960-61

County	Enrollment Grades 9-12		Pupil Enrollment In Sciences											
			Gen. Sci.		Biol.		Chem.		Physics		Adv. Phys. Sci.		Aero.	
	'57-'58	'60-'61	'57-'58	'60-'61	'57-'58	'60-'61	'57-'58	'60-'61	'57-'58	'60-'61	'57-'58	'60-'61	'57-'58	'60-'61
Adair County	638	734	208	207	121	174	26	67	15	--	--	--	--	--
Allen County	473	548	93	138	91	118	15	35	--	15	31	61	--	--
Anderson County	454	466	75	93	90	89	27	50	--	--	--	--	--	--
Ballard County	452	421	44	48	61	57	31	19	13	19	--	--	--	--
Barren County	1,446	1,453	255	369	179	250	259	44	21	39	19	--	--	--
Bath County	439	404	61	66	116	98	--	--	--	--	--	61	--	--
Bell County	2,192	2,127	791	626	477	372	23	69	43	21	23	--	--	--
Boone County	845	1,095	177	294	144	194	30	60	34	37	--	35	--	--
Bourbon County	885	947	130	222	213	183	78	73	56	55	17	5	--	--
Boyd County	2,727	2,792	434	887	509	572	151	182	78	152	--	66	--	--
Boyle County	988	1,001	155	344	217	228	60	94	52	50	--	16	--	--
Bracken County	355	338	37	103	94	71	66	39	20	--	32	21	--	--
Breathitt County	867	968	111	176	157	192	32	81	--	18	--	122	--	--
Breckinridge County	621	620	82	103	77	78	23	54	--	16	24	--	--	--
Bullitt County	663	763	178	292	107	178	19	96	18	32	42	--	--	--
Butler County	557	806	55	138	106	164	--	12	--	--	--	49	61	--
Caldwell County	669	600	77	133	65	102	40	38	18	16	--	--	--	--
Calloway County	983	1,088	101	342	219	182	61	73	46	57	--	--	--	--
Campbell County	2,432	2,648	890	956	424	421	244	205	113	117	--	14	--	--
Carlisle County	297	281	10	61	28	36	22	38	--	12	--	--	--	--
Carroll County	384	430	65	69	52	114	29	22	--	--	13	--	--	--
Carter County	1,159	1,234	310	379	216	200	21	55	24	17	--	19	--	--
Casey County	634	812	97	210	89	146	--	18	15	47	--	--	--	--
Christian County	1,585	1,992	432	1,006	244	300	157	222	63	88	--	--	--	--
Clark County	918	957	174	217	144	165	79	49	--	26	--	--	--	--
Clay County	613	790	171	316	163	185	60	43	27	13	34	51	--	--
Clinton County	405	434	100	115	106	122	19	16	--	--	--	--	--	--
Crittenden County	558	468	44	156	75	145	15	53	17	--	--	--	--	--
Cumberland County	310	327	42	142	67	38	--	32	12	--	10	--	--	--
Daviess County	2,533	2,859	395	570	682	697	196	214	176	175	83	216	75	19
Edmonson County	312	396	100	162	67	56	11	15	--	--	--	--	--	--
Elliott County	380	356	58	145	75	69	6	12	--	--	--	--	--	--
Estill County	698	616	179	267	98	124	34	17	14	--	--	--	--	--
Fayette County	4,196	4,220	680	1,502	973	721	267	257	176	226	137	285	43	--
Fleming County	480	507	98	147	78	78	32	17	--	9	--	--	--	--
Floyd County	2,787	2,844	690	745	603	644	90	131	--	33	28	163	--	--
Franklin County	1,161	1,273	336	243	361	297	62	85	53	35	--	93	--	--
Fulton County	568	621	32	188	90	146	25	37	14	18	--	--	--	--
Gallatin County	215	195	--	28	102	25	32	35	--	--	--	--	--	--
Garrard County	466	434	138	137	128	91	--	--	--	--	--	27	--	--
Grant County	491	523	75	109	66	62	67	15	--	5	--	--	--	--
Graves County	1,658	1,684	209	480	319	395	175	141	56	32	16	--	--	--
Grayson County	618	666	48	190	110	150	27	31	5	29	17	--	--	--
Green County	385	448	84	113	47	51	--	25	23	--	--	--	--	--
Greenup County	1,655	1,891	542	461	428	328	94	73	35	44	97	97	--	52
Hancock County	297	314	23	86	47	96	--	11	--	--	55	39	--	--
Hardin County	1,675	1,861	189	444	357	264	98	97	56	90	--	--	--	--
Harlan County	3,800	3,588	936	1,178	794	827	124	236	238	115	34	111	--	--
Harrison County	649	449	68	63	92	112	22	29	21	15	22	40	--	--
Hart County	576	812	75	207	21	161	--	50	--	23	17	25	--	--
Henderson County	1,594	1,747	295	529	308	512	110	163	55	50	11	13	--	--
Henry County	563	647	68	126	38	71	--	11	28	--	43	--	--	--
Hickman County	301	317	78	115	41	57	--	27	19	12	--	--	--	--
Hopkins County	1,893	2,087	405	495	449	454	156	118	74	70	94	--	--	--
Jackson County	483	517	164	191	54	126	12	34	--	18	--	--	--	--
Jefferson County	19,596	22,970	5,942	7,651	4,874	5,483	1,611	2,013	851	1,088	267	1,015	81	55
Jessamine County	441	536	125	223	77	120	12	14	7	18	18	--	--	--
Johnson County	1,125	1,207	169	230	219	321	28	60	8	11	--	62	--	--
Kenton County	3,471	3,706	689	1,124	1,299	763	236	220	201	221	121	20	--	28

Carter County	1,159	1,234	310	379	216	200	21	55	24	17	--	19	--	--
Casey County	634	812	97	210	89	146	--	18	15	47	--	--	--	--
Christian County	1,585	1,992	432	1,006	244	300	157	222	63	88	--	--	--	--
Clark County	918	957	174	217	144	165	79	49	--	26	--	--	--	--
Clay County	613	790	171	316	163	185	60	43	27	13	34	51	--	--
Clinton County	405	434	100	115	106	122	19	16	--	--	--	--	--	--
Crittenden County	558	468	44	156	75	145	15	53	17	--	--	--	--	--
Cumberland County	310	327	42	142	67	38	--	32	12	--	10	--	--	--
Daviess County	2,533	2,859	395	570	682	697	196	214	176	175	83	216	75	19
Edmonson County	312	396	100	162	67	56	11	15	--	--	--	--	--	--
Elliott County	380	356	58	145	75	69	6	12	--	--	--	--	--	--
Estill County	698	616	179	267	98	124	34	17	14	--	--	--	--	--
Fayette County	4,196	4,220	680	1,502	973	721	267	257	176	226	137	285	43	--
Fleming County	480	507	98	147	78	78	32	17	--	9	--	--	--	--
Floyd County	2,787	2,844	690	745	603	644	90	131	--	33	28	163	--	--
Franklin County	1,161	1,273	336	243	361	297	62	85	53	35	--	93	--	--
Fulton County	568	621	32	188	90	146	25	37	14	18	--	--	--	--
Gallatin County	215	195	--	28	102	25	32	35	--	--	--	--	--	--
Garrard County	466	434	138	137	128	91	--	--	--	--	--	27	--	--
Grant County	491	523	75	109	66	62	67	15	--	5	--	--	--	--
Graves County	1,658	1,684	209	480	319	395	175	141	56	32	16	--	--	--
Grayson County	618	666	48	190	110	150	27	31	5	29	17	--	--	--
Green County	385	448	84	113	47	51	--	25	23	--	--	--	--	--
Greenup County	1,655	1,891	542	461	428	328	94	73	35	44	97	97	--	52
Hancock County	297	314	23	86	47	96	--	11	--	--	55	39	--	--
Hardin County	1,675	1,861	189	444	357	264	98	97	56	90	--	--	--	--
Harlan County	3,800	3,588	936	1,178	794	827	124	236	238	115	34	111	--	--
Harrison County	649	449	68	63	92	112	22	29	21	15	22	40	--	--
Hart County	576	812	75	207	21	161	--	50	--	23	17	25	--	--
Henderson County	1,594	1,747	295	529	308	512	110	163	55	50	11	13	--	--
Henry County	563	647	68	126	38	71	--	11	28	--	43	--	--	--
Hickman County	301	317	78	115	41	57	--	27	19	12	--	--	--	--
Hopkins County	1,893	2,087	405	495	449	454	156	118	74	70	94	--	--	--
Jackson County	483	517	164	191	54	126	12	34	--	18	--	--	--	--
Jefferson County	19,596	22,970	5,942	7,651	4,874	5,483	1,611	2,013	851	1,088	267	1,015	81	55
Jessamine County	441	536	125	223	77	120	12	14	7	18	18	--	--	--
Johnson County	1,125	1,207	169	230	219	321	28	60	8	11	--	62	--	--
Kenton County	3,471	3,706	689	1,124	1,299	763	236	220	201	221	121	20	--	28

County	Enrollment Grades 9-12 '57-'58	Enrollment Grades 9-12 '60-'61	Pupil Enrollment In Sciences: Gen. Sci. '57-'58	Gen. Sci. '60-'61	Biol. '57-'58	Biol. '60-'61	Chem. '57-'58	Chem. '60-'61	Physics '57-'58	Physics '60-'61	Adv. Phys. Sci. '57-'58	Adv. Phys. Sci. '60-'61	Aero. '57-'58	Aero. '60-'61
Knott County	916	968	230	259	284	66	27	--	60	12	--	--	--	--
Knox County	1,223	1,393	427	234	310	118	63	67	15	46	--	--	--	--
Larue County	473	513	105	60	31	81	14	50	--	17	--	--	--	--
Laurel County	1,525	1,497	235	326	287	404	81	44	--	49	18	11	--	--
Lawrence County	618	642	158	164	147	120	50	18	14	18	28	--	--	--
Lee County	391	421	125	181	85	101	25	27	13	--	--	--	--	--
Leslie County	572	603	218	180	106	180	--	18	--	--	--	--	--	--
Letcher County	2,110	2,035	577	674	528	567	55	78	37	40	--	7	--	--
Lewis County	630	655	125	227	109	109	--	--	--	--	62	--	--	--
Lincoln County	1,031	975	196	294	176	220	16	72	--	19	39	22	--	--
Livingston County	498	420	39	76	48	45	--	15	--	--	--	--	--	--
Logan County	1,078	1,111	250	362	253	215	34	29	17	52	34	58	--	--
Lyon County	314	272	20	59	72	67	--	22	--	--	--	--	--	--
Madison County	1,260	1,395	386	466	270	413	49	61	11	24	--	--	--	--
Magoffin County	482	546	122	150	122	139	19	31	17	39	--	--	--	--
Marion County	1,162	986	309	301	208	215	24	73	30	14	--	18	--	--
Marshall County	924	949	193	228	185	202	86	66	--	30	--	--	--	--
Martin County	542	615	124	281	119	64	--	--	--	--	--	--	--	--
Mason County	894	885	173	318	164	232	52	79	9	20	--	--	--	--
McCracken County	2,745	2,834	464	802	488	285	249	365	103	142	85	23	--	--
McCreary County	671	779	89	279	103	161	--	19	36	15	24	13	--	--
McLean County	583	584	180	168	123	154	--	64	--	--	20	--	--	--
Meade County	559	681	155	175	80	140	39	--	--	33	--	--	--	--
Menifee County	217	214	32	67	58	56	--	--	--	10	--	--	--	--
Mercer County	773	791	197	271	133	173	39	22	29	39	--	--	--	--
Metcalfe County	240	295	42	31	--	61	--	--	17	--	--	--	--	--
Monroe County	631	610	167	187	88	126	65	43	19	32	--	--	--	--
Montgomery County	651	734	117	209	181	191	24	107	12	--	27	--	--	--
Morgan County	484	491	106	141	67	128	9	12	--	--	--	13	--	--
Muhlenberg County	1,843	1,913	353	382	360	241	96	75	16	--	44	--	--	--
Nelson County	727	740	110	272	155	147	35	53	12	39	43	--	--	--
Nicholas County	323	400	58	88	58	59	36	36	--	20	--	--	--	--
Ohio County	1,020	1,143	102	219	169	237	35	59	14	70	26	37	--	--
Oldham County	548	626	50	149	142	199	40	21	--	11	28	80	--	--
Owen County	373	410	59	58	39	68	15	12	--	12	--	12	--	--
Owsley County	199	221	23	49	53	45	20	21	--	--	--	24	--	--
Pendleton County	499	523	150	202	124	150	--	25	--	12	--	--	--	--
Perry County	1,911	2,114	548	680	492	510	52	112	19	54	37	25	15	--
Pike County	4,024	4,006	622	1,325	933	889	134	201	27	67	43	148	--	--
Powell County	259	325	37	177	49	56	20	37	--	--	37	--	--	--
Pulaski County	1,791	2,016	333	337	400	321	56	105	15	26	48	61	--	--
Robertson County	128	129	36	42	34	35	--	--	--	--	--	--	--	--
Rockcastle County	715	682	104	163	49	117	36	15	10	26	--	--	--	--
Rowan County	627	480	155	164	105	127	19	12	16	8	--	--	--	--
Russell County	633	635	108	203	157	159	17	33	--	24	--	--	--	--
Scott County	656	719	100	86	150	192	38	70	46	9	--	--	--	--
Shelby County	1,367	935	125	256	298	233	76	69	31	13	30	28	--	--
Simpson County	596	608	144	264	129	43	61	38	21	--	--	--	--	--
Spencer County	218	206	21	70	20	102	11	--	--	21	--	--	--	--
Taylor County	769	879	88	113	161	69	107	68	--	27	--	19	--	--
Todd County	615	639	218	199	155	164	28	44	--	10	45	41	--	--
Trigg County	439	443	60	77	85	127	71	26	--	20	--	--	--	--
Trimble County	261	488	18	55	35	29	--	26	35	37	--	--	--	--
Union County	611	664	105	195	62	124	48	26	--	13	--	--	--	--
Warren County	1,893	2,138	273	652	304	574	168	115	44	57	10	--	--	--
Washington County	522	541	122	124	142	138	35	33	--	--	22	--	--	--
Wayne County	581	2,353	158	847	46	551	41	91	19	47	--	94	--	--
Webster County	713	760	111	212	130	152	13	44	--	--	49	43	--	--
Whitley County	1,585	1,692	362	608	335	479	72	41	--	--	21	94	--	--
Wolfe County	310	308	56	112	24	---	10	--	--	--	9	--	--	--
Woodford County	509	520	102	184	84	136	15	70	12	6	--	--	--	--
TOTAL PUPIL ENROLLMENT	131,909	140,448	28,761	42,091	27,660	30,244	7,539	9,053	3,571	4,452	2,134	3,609	275	154

Menifee County	217	214	32	67	58	56	--	--	--	10	--	--	--	--
Mercer County	773	791	197	271	133	173	39	22	29	39	--	--	--	--
Metcalfe County	240	295	42	31	--	61	--	--	17	--	--	--	--	--
Monroe County	631	610	167	187	88	126	65	43	19	32	--	--	--	--
Montgomery County	651	734	117	209	181	191	24	107	12	--	27	--	--	--
Muhlenberg County	1,843	1,913	353	382	360	241	96	75	16	--	44	--	--	--
Nelson County	727	740	110	272	155	147	35	53	12	39	43	--	--	--
Nicholas County	323	400	58	88	58	59	36	36	--	20	--	--	--	--
Ohio County	1,020	1,143	102	219	169	237	35	59	14	70	26	37	--	--
Oldham County	548	626	50	149	142	199	40	21	--	11	28	80	--	--
Owen County	373	410	59	58	39	68	15	12	--	12	--	12	--	--
Owsley County	199	221	23	49	53	45	20	21	--	--	--	24	--	--
Pendleton County	499	523	150	202	124	150	--	25	--	12	--	--	--	--
Perry County	1,911	2,114	548	680	492	510	52	112	19	54	37	25	15	--
Pike County	4,024	4,006	622	1,325	933	889	134	201	27	67	43	148	--	--
Powell County	259	325	37	177	49	56	20	37	--	--	37	--	--	--
Pulaski County	1,791	2,016	333	337	400	321	56	105	15	26	48	61	--	--
Robertson County	128	129	36	42	34	35	--	--	--	--	--	--	--	--
Rockcastle County	715	682	104	163	49	117	36	15	10	26	--	--	--	--
Rowan County	627	480	155	164	105	127	19	12	16	8	--	--	--	--
Russell County	633	635	108	203	157	159	17	33	--	24	--	--	--	--
Scott County	656	719	100	86	150	192	38	70	46	9	--	--	--	--
Shelby County	1,367	935	125	256	298	233	76	69	31	13	30	28	--	--
Simpson County	596	608	144	264	129	43	61	38	21	--	--	--	--	--
Spencer County	218	206	21	70	20	102	11	--	--	21	--	--	--	--
Taylor County	769	879	88	113	161	69	107	68	--	27	--	19	--	--
Todd County	615	639	218	199	155	164	28	44	--	10	45	41	--	--
Trigg County	439	443	60	77	85	127	71	26	--	20	--	--	--	--
Trimble County	261	488	18	55	35	29	--	26	35	37	--	--	--	--
Union County	611	664	105	195	62	124	48	26	--	13	--	--	--	--
Warren County	1,893	2,138	273	652	304	574	168	115	44	57	10	--	--	--
Washington County	522	541	122	124	142	138	35	33	--	--	22	--	--	--
Wayne County	581	2,353	158	847	46	551	41	91	19	47	--	94	--	--
Webster County	713	760	111	212	130	152	13	44	--	--	49	43	--	--
Whitley County	1,585	1,692	362	608	335	479	72	41	--	--	21	94	--	--
Wolfe County	310	308	56	112	24	---	10	--	--	--	9	--	--	--
Woodford County	509	520	102	184	84	136	15	70	12	6	--	--	--	--
TOTAL PUPIL ENROLLMENT	131,909	140,448	28,761	42,091	27,660	30,244	7,539	9,053	3,571	4,452	2,134	3,609	275	154

XI (2)

TABLE II

ENROLLMENTS IN SCIENCE COURSES AND THE PERCENTAGE OF THESE ENROLLMENTS TO ENROLLMENTS IN GRADES 9-12 AND TO ENROLLMENTS IN GRADES WHERE SUBJECTS IS USUALLY OFFERED IN KENTUCKY FOR 1957-58 AND 1960-61

Subject	Course Enrollment For: 1957-58	1960-61	Percent Of Enrollment 9-12 1957-58	1960-61	Percent Of Enrollment Subject-Grade 1957-58	1960-61	Grade Where Usually Offered
General Science	28,761	42,091	21.7	29.9	65.0	85.9	9
Biology	27,660	30,244	21.1	21.5	77.6	87.1	10
Chemistry	7,539	9,053	5.8	6.4	26.8	31.2	11
Physics	3,571	4,452	2.8	3.1	16.0	16.0	12
Physical Science	2,134	3,609	1.6	2.5	9.2	13.0	12
Other Sciences	275	154	---	---	1.2	.06	12
	69,940	89,603					

It should be noted that some schools are offering advanced courses in biology, chemistry, and physics, but all these courses are included with the corresponding course above.

The percentage of enrollment as per subject and grade is not an absolute figure since some few schools offer courses in different grades. This is especially true in smaller schools when chemistry and physics is offered in alternate years.

79,242 students in 145 public high schools in Kentucky were offered both chemistry and physics in 1960-61 or a total of 56.4% of all the students enrolled. A larger percentage of students will have an opportunity to take chemistry and physics than the above figures indicate since many of the smaller high schools offer chemistry one year and physics the next.

General Science: In 1957-58 44,498 students were enrolled in the ninth grade and 28,761 were taking general science which was approximately 65% of the freshman class taking the course.

In 1960-61 48,997 students were enrolled in the ninth grade and 42,091 were enrolled in general science. This is approximately 85% of the freshman class. This does not take into consideration that some students may be repeating the course, nor does it take into consideration that a few upper classmen may be taking general science. However, these figures also may mean that some 7,000 ninth graders are not taking general science. A few schools do not offer general science in the ninth grade and offer either a physical science or biology. This figure of 7,000 also seems to indicate that too many students are allowed to substitute other subjects for their basic science requirement.

Biology: In 1957-58 36,531 students were enrolled in the tenth grade class and 27,660 were enrolled in biology. Since biology is usually offered in the tenth grade, this would mean that approximately 75% of the class was enrolled in the course. This also does not take into consideration that some students may be repeating the course and that some upper classmen may be taking the course.

In 1960-61 34,740 students were enrolled in the tenth grade and 30,244 were enrolled in biology. Based on the enrollment of the tenth grade, this would mean that about 87% of the tenth grade were enrolled in the course. This is not a completely true figure as was indicated above. However, by using these figures it indicates that approximately 4,516 tenth graders are not enrolled in biology. This also may mean that too many students are permitted to substitute other subjects for one or more of the required basic science units for graduation.

Chemistry: In 1957-58 32,571 students were enrolled in the eleventh grade and 7,539 were enrolled in chemistry. This indicates that approximately 26.8% of the junior class were taking chemistry. Chemistry is usually taught in the junior year. However, the above figures do not take into consideration that some of the smaller high schools alternate chemistry and physics.

In 1960-61 28,964 students were enrolled in the eleventh grade. 9,053 were enrolled in chemistry.

Physics: In 1957-58 23,486 students were enrolled in the twelfth grade and 3,571 were taking physics which is approximately 15% of the twelfth grade students. This does not mean that only seniors were taking physics; however, physics is usually offered to seniors except in those schools that alternate chemistry and physics in the junior and senior years.

In 1960-61 27,747 students were enrolled in the twelfth grade. 4,452 students were taking physics which is approximately 16% based upon the enrollment in the twelfth grade.

As indicated by Table II a distinct increase is shown percentage-wise in students taking general science. The increase was from 65.8% to 85.9% based upon the ninth grade enrollment. The latest available figures from the United States Office of Education which was in 1956 shows that 67.3% of the ninth graders were enrolled in general science.

Biology has always taken a commanding position among the various sciences offered in Kentucky schools. Percentage-wise, there was a greater percentage of the sophomore class taking biology than there was taking general science in the freshman class. However, there was a significant increase from 77.6% increase in 1957 to 87.1% increase in 1960 calculated on the enrollment in the tenth grade; the United States in 1956 was 74.0%. Probably the large percentage in biology, based on the tenth grade enrollment, can partly be accounted for in the fact that biology is offered to freshmen and also to juniors and seniors. It is also true that some schools offer an advanced course in biology. All biology courses were considered as being taught in the tenth grade.

Chemistry has had an increase of 5% in enrollment. Although 31.2%, based on the eleventh grade, is taking chemistry, there are 19,927 students left in the eleventh grade who are not taking it.

Very little change took place in the ratio between the total high school and chemistry enrollments during the first fifty-six years of the twentieth century. 7.7% of the high school students were studying chemistry in1900. From that time to 1956 the precentage of high school enrollments in this subject fluctuated narrowly between a low of 6.9 in 1910 to a high of 7.6 in 1949. It stood at 7.5 in 1956.* In the spring of 1959 there was 10.2%. The percentage of eleventh grade students studying chemistry has increased from 31.9 in 1954 to 39.9 in 1959 in the United States public schools.**

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* Kenneth E. Brown and Ellsworth S. Osbourn. Offerings and Enrollments in Science and Math. Pamphlet #120. Government Printing Office, Washington, D. C.

** Koelsche and Salburg. Facilities and Equipment Available for Teaching Science in Public High Schools, 1958-59. Research Foundation, University of Toledo.

The 1956 United States figures indicates that 24.5% of the twelfth grade were enrolled in physics while the per cent in Kentucky remained 16% for 1957 and 1960.

The number enrolled in chemistry classes in Kentucky follows the national trend closer than the enrollment in physics. This is caused, to some extent, in the fact that many who were trained as vocational teachers have switched to teaching chemistry. Vocational teachers are required to take several courses in chemistry in order to graduate from college.

XII

LIST OF EQUIPMENT AND SUPPLIES FOR THE VARIOUS SCIENCE COURSES

Materials and Supplies to Aid Elementary Science Instruction

Suggested basic list of equipment and materials which may be purchased through National Defense Education Act, Title III.

It is emphasized that the following list is not to be construed to mean a maximum or a minimum list. With the exception of a few added pieces of equipment or materials, the items listed below were selected from the Kentucky basic or minimum requirement list.

Bell in vacuo, with jar and suspended bell
Burners, Bunsen
Buzzer, Electric
Cages, Animal, rigid
Clamps, Burette single
Compasses, magnetic, 15 mm.
Compasses, magnetic, 45 mm.
Dishes, Porcelain
Electric Bell
Electromagnets, U-form
First aid cabinet, with supplies
Flasks, Florence, flat bottom, 500 ml.
Funnels, glass, 75 mm. diameter
Globe, terrestrial
Graduated cylinders, 100 ml capacity
Hot plate, electric
Insect net
Lamp, electrical, miniature
Lamp chimney
Lenses, reading glass
Lenses, set consisting of concavo-convex, convexo-concave, double concave, double convex, plano-concave, and plano-convex
Magnets, Alnico, disc
Magnets, Cylindrical, small, pair
Magnets, Horseshoe
Magnet, Bar, alnico, pair
Magnetic needle
Meter stick, English and metric
Microscope, Elementary
Mirror, Plane, glass, 10 x 15 cm
Net, insect
Prisms, Equilateral
Prisms, Equilateral, lucite
Pulley, Tandem, double
Ring stands with three rings
Rod, soft glass
Sockets, miniature
Test tubes (specify size)
Test tube supports
Thermometers, Centigrade, Fahrenheit, combined scale

Other items that may be needed for making simple science instructional materials will vary from place to place and class to class. It is possible, however, to suggest a few materials and some of the places where they can be obtained.

From the home

Old pans of various sizes
Basins
Tablespoons
Teaspoons
Cups and saucers
Dinner plates
Soup plates
Bottles, various shapes and sizes
Tin cans, various sizes with and without covers
Glass jars, various shapes and sizes
Garden tools
Hand tools
Ink bottles
Glass tumblers
Combs
Saltshakers
Soap
Used electric bulbs
Ink
Wire coat hangers
Fruit jars
Flower pots
Clothes pins
Leather, soft, from old shoes
Milk bottles
Spools—wood
Old clocks
Razor blades
Old electrical appliances
Musical instruments
Cloth, various kinds
Fur
Newspapers
Paper bags
Used tooth brushes
Cork dinner—table mats
Plastic drinking cups
Aluminum and plastic tubes from used bird pens
Aluminum milk bottle caps

From the hardware or 5 & 10 cent stores

Nails—assorted sizes
Spikes—assorted sizes
Screws—assorted sizes
Bolts and nuts—assorted sizes
Screw eyes
Springs
Tape Measure
Fish-line
Staples—assorted sizes
Tacks—carpet
Tacks—thumb
String and twine
Rope—small diameter
Mirrors
Glass jars—assorted sizes
Window glass
Washers
Hooks—assorted sizes
Flash-light batteries
Flash-light bulbs
Sheet metal
Metal rods
Thermometers
Egg beater
Candles
Wash tub—small
Curtain rods
Compass—magnetic
Kerosene lamps
Lamp chimneys
Lantern globes
Wire screening
Corks
Funnels—metal and plastic
Rubber tubing
Metal tubing
Needles, sewing
Needles, darning
Needles, knitting
Level
Sand paper
Pulleys

Turn buckles
Steel wool
Glue and household cement
Wire, brass, copper and iron
Tools
Paint
Varnish
Flash lights
Hack-saw blades
Scissors
Shears
Balls–metal
Balls–wood
Dish pan
Oil cans
Oil
Cup–tin
Cup–aluminum
Pyrex dishes
Pyrex bottles
Forceps–small
Tack puller
Sieve
Wicking for alcohol lamps
Asbestos mats
Battery jars
Pins
Block and tackle
Jack screw
Thermos bottles

From the automobile repair shop

Old rubber tires
Old rubber inner tubes
Valves from inner tubes
Used storage batteries
Battery acid
Safety glass from old cars
Spark plug
Ammeter
Carburetor
Fuses
Curved reflectors from headlights
Fuel pump
Electric motor
Electric generator
Gears
Ball bearings
Springs from seats
Magnet from speedometer
Headlight lenses
Headlight bulbs
Tools
Metal tubing
Wire from old coils
Ignition coil
Engine
Rear view mirror
Fender mirror
Used oil

From the radio repair shop

Radio sets
Wire from old coils
Transformers
Old radio tubes
Electrical instruments
Coils
Transformer cores
Condensers
Rheostats
Solder
Metal plates
Plastic from old cabinets

From the grocery store

Ammonia
Baking powder
Baking soda
Bleaching powder
Blueing
Corn syrup
Epsom salts
Matches
Mineral oil
Paraffin
Beeswax
Sealing wax
Starch
String
Sugar
Paper bags
Table salt
Turpentine
Vinegar
Boards from boxes
Cardboard boxes
Wood boxes
Tin containers

Gelatine
Cooking oil
Lard
Seeds

From the lumber yard

Asbestos sheets
Boards
Hardware
Insulating materials
Plywood
Press board
Rope
Paint
Varnish
Wire screening
Sawdust
Lime
Cement
Brick
Broken sewer pipes
Round dowel rod
Wood blocks
Wood prisms

From the machine shop

Ball bearings
Gears
Sheet iron
Sheet brass
Sheet copper
Brass rod
Iron rod
Iron fillings
Scrap metal pieces

From the drugstore

Agar
Copper sulphate
Mineral oil
Saccharine
Hydrochloric acid
Nitric acid
Sodium hydroxide
Silver nitrate
First-aid kit
Cellophane
Beef extract
Drug capsule containers
Sheet rubber
Powdered sulphur
Boric acid
Manganese dioxide
Adhesive tapes
Wood tongue depressors
Thermometers
Dyes
Ink
Iodine
Marble chips
Medicine droppers
Shaving mirrors
Glass tubes
Rubber stoppers
Medicine bottles
Medicine vials
Peptone
Sponges
Test tubes
Litmus paper
Potassium chlorate
Plaster of Paris

From the optical shop

Old cameras
Lenses
Reading glass lenses
Old eye-glass lenses

From the plumber and tinsmith

Scrap iron pipe
Scrap lead pipe
Sheet metal
Rubber suction cup
Old faucets

From the electric shop and surplus property warehouses Madisonville and Frankfort

Batteries, dry cell
Electric bulbs
Insulated wire
Switches
Lamp sockets
Insulation tape
Electric meters
Old electrical appliances

Miniature light sockets
Electric bell
Electric buzzer
Push buttons
Heating elements
Magnetic compass

From the toy shop

Gyroscopes
Marbles
Small wagons
Ping pong balls
Mechanical toys
Colored chalk
Steam engine
Steam turbine
Electrical toys
Rubber balloons
Toy musical instruments
Rubber balls
Plastic toys
Football pump adaptors

From the bicycle repair shop

Used bicycle wheels
Spokes from bicycle wheels
Inner tubes
Valves from tires
A sprocket wheel
Bicycle pump
Rubber grips from handlebars
Bicycle lamp

From the textile store

Silk cloth
Cotton cloth
Woolen cloth
Synthetic fabrics
Linen cloth
Cotton thread
Silk thread
Linen thread

From the school

Cardboard
Blotters
Ink
Colored chalk
Erasers
Burned-out electric bulbs
Paper
Oil
Chalk
Fuses
Paper towels
Pencils
Chalk boxes
Gummed labels
Rulers
Globes
Maps
Rubber bands[1]

Material List for General Science

The materials listed here are needed to perform the experiments and observations usually included in the laboratory experience of General Science. Most of the items can be brought from home or ought in local stores.

1 pt. Alcohol, 95% grain (or rubbing)
1 strip Aluminum, 1 x 5 in.
1 bottle Ammonia, household (or 1 lb. amonium hydroxide)
1 Ball, rubber, light-colored
1 Basketball (or football)
1 Bell (or buzzer), electric
4 Blocks, wooden, 6 x 1 x ½ in.
1 Board, 18 in. sq., at least 1 in. thick
4 Boards (two: 6 ft. x 1 ft. x ½ in.; one shorter; one longer)
2 Boards, thin, 4 x 10 in.

[1] "Unesco Source Book for Science Teaching." Unesco Publishing Co.

2 Bottles, wide-mouth, same size
1 Box, cigar
2 Boxes, flat, cardboard, same size
1 Brick
1 oz. Camphor, gum
1 Can, varnish; screw top or stopper
1 doz. Candles, paraffin
1 bottle Carbona cleaning fluid (or 1 lb. carbon tetrachloride)
3 pieces Cardboard, white, 2 ft. sq.
1 Cardboard tube
1 Cart, small
1 piece Cheesecloth, 8 in. sq.
1 yd. Cloth, cotton
1 lump Coal, soft
1 Coin
1 Compass, drawing
1 Compass, magnetic
2 strips Copper 1 x 5 in.
1 piece Cord, flexible lamp, 6-8 in.
1 doz. Corks, assorted
2 Corks, large, flat
1 piece Cotton
1 Cup, measuring
1 Cup, shiny metal (or tin can)
1 Dish, heavy, 3 in. diam.
2 Disks, wooden, one 12 in. diam.; one 2 in. diam.
1 Dowel, wooden, 3 ft. long, ¼ in. diam.
1 Drill (or brace and bit)
1 Drum
3 Dry cells, No. 1½ volts
1 can Ether
1 Fan, electric (or piece of cardboard)
1 Flashlight
2 Flowerpots, medium size
1 Funnel, glass 3 in.
1 piece Glass, 3 in. sq.
2 sheets Glass, 12 in. sq.
4 Glasses, drinking (or beakers)
10 lbs. Gravel (or coarse sand)
1 Hammer
1 Heater (or toaster or electric iron)
1 Hook
2 Hot pads
6 cubes Ice
9 cups Ice, crushed
1 bottle Ink, red (or vegetable coloring)
1 bottle Iodine, tincture of
1 strip Iron, 1 x 5 in.
1 Jar, glass, 1-gal.
1 Jar, glass, with screw top
2 Jars, large stoneware (or glass) with tight covers
1 qt. Kerosene
1 Knife, sharp
1 Knitting needle, steel (or piece of stiff wire)
1 Lamp, kerosene
1 Lamp chimney
3 strips Lead, 1 x 5 in.
3 Light bulbs, 1½ volts
2 doz. Marbles (or small box of shot)
1 box Matches, safety
2 Medicine droppers
1 Metal rod
1 pair Metal shears
1 Mirror, plane
1 Nail, spike
6 Nails, long iron, new
1 box Nails, small
1 can Oil, machine
1 Pail (or large potato-chip can)
1 Pail, small
½ pt. Paint, oil
1 Pan, iron (or spoon)
1 Pan, large, with lid, and rack to fit
2 Pans (such as cake tins), same size
1 sheet ea. Paper: black, white, and various shades of red, yellow, blue, green, and gray
1 sheet Paper, blotting (or roll of towel paper)
6 sheets Paper, shiny, white
4 sheets Paper, stiff, white
1 Pencil, with eraser
1 oz. Pepsin, dry
1 paper Pins
1 Plant (geranium or nasturtium)
1 pair Pliers
1 Protractor (optional)
1 Pulley
1 Pump, air, hand-pressure

6 Punk sticks
1 Push button, electric
1 pkg. Razor blades, safety, single-edge
1 box Rubber bands, assorted
1 Ruler
5 lbs. Sand, fine
1 cup Sand, clay, and small gravel, mixed
2 sheets Sandpaper
1 Saucepan, small
1 Saucepan, large, with cover
1 Saucer, white
1 Saw
1 piece Screen wire (or wire gauze), 6 in. sq.
1 Screwdriver
1 doz. Seeds (lima bean, pea, corn, radish, cabbage, or mustard)
3 Sockets, porcelain, for small light bulbs
1 pail Soil
1 Sponge, small
1 Spring, coil (from window-shade roller)
1 Stick, flat, 4 ft. long
2 Sticks, small wooden
1 ball String, heavy (or cord)
2 Switches, knife, single-pole, single-throw
1 Tablespoon
1 box Tacks, household, iron or steel
1 Tank, glass, square or rectangular, about 6 x 8 in. and 8 in. high
1 roll Tape, cellophane
1 Teaspoon
1 spool Thead
1 strip Tin, 1 x 5 in.
3 Tin cans
3 pieces Tin foil
1 pair Tongs (or large forceps)
1 box Toothpicks
1 pair Tweezers
1 Twig, maple
1 Watch (or clock), with second hand
1 Watch glass (or metal lid from Jar)
2 Wheels, roller skate
1 piece Wire, iron, fine 6-8 in.
1 roll Wire, iron, bare No. 18 or 22 (or stovepipe wire)
1 spool Wire, copper, insulated, No. 18
1 piece Wire, copper, insulated, No. 30 or 40, 3-4 ft.
3 pieces Wood, 6 x 1 x ½ in.
2 pieces Wood, rough
1 piece Wood, soft, ½ x ½ x 6 in.
1 doz. Wood splinters
1 Yardstick
1 strip Zinc, 1 x 5 in.

Foods

2 Apples
1 Banana
¼ lb. Beans, dried
1 oz. Beef extract (or sugar)
3 slices Bread
4 oz. Butter
1 Carrot
1 bunch Celery
4 oz. Cheese
3 Eggs
1 each Fruits, as available
5 oz. Gelatine, unflavored
4 oz. Lard
2 pieces Meat, as available
½ pt. Milk
1 pkg. Nuts, assorted
1 oz. Oil, salad
1 Onion
2 Potatoes
1 box, Salt, table
1 box, Soda, baking
1 box Starch, corn (or laundry)
1 lb. Sugar, cane or beet
1 can Syrup, corn
¼ lb. Tea leaves
2 Tomatoes
1 each Vegetables, green, available
1 bottle Vinegar, white

Chemicals

4 oz. Acid, citric, crystals
1 lb. Acid, hydrochloric, C.P.
1 lb. Acid, Nitric, C.P.
1 lb. Acid, sulphuric, C.P.

1 lb. Ammonium chloride
1 lb. Calcium oxide
1 lb. Copper sulphate
4 oz. Fehling's solution A
4 oz. Fehling's solution B
1 lb. Iron filings
1 lb. Iron powder
4 oz. Mercuric oxide, red
5 lbs. Mercury (optional)
1 oz. Silver nitrate, crystals, C.P.
1 lb. Sulphur, powdered

Apparatus

1 Balance, platform (or trip scales), with brass weights, 1-500 g., 1-16 oz., and 1-5 lbs.
1 Balance, spring
1 Beaker, Pyrex, 150 cc.
1 Burner, Bunsen (or alcohol lamp or other heat source)
2 Clamps, burette, single, adjustable
1 box, Filter paper, 15 cm. diam. (or roll of towel paper)
1 Flask, boiling, flat-bottom (Erlenmeyer), 500 cc.
1 Galvanometer
1 Magnet, alnico (or other strong magnet)
1 Magnet, bar
1 Magnet, U–
1 Magnifying glass
2 Magnifying glasses, same size as above, one with thinner, one with thicker lens (optional)
1 Microscope, compound (optional)
½ oz. box Microscope cover glasses, ¾ in. diam.
½ gross Microscope glass slides
2 Needles, dissecting (optional)
1 pkg. Pith sticks
8 Petri dishes with lids
1 Prism
2 Ringstands with small, medium, and large rings
1 lb. bag Rubber stoppers, assorted, solid, one-hole, two-hole, No. 00-8
2 Stirring rods, glass, 8 in. long x 3/16 in. diam.
1 Telegraph key
1 Test-tube brush
1 Telegraph sounder
3 Test-tube holders
1 Test-tube rack
2 doz. Test tubes, ordinary glass, 6 x ¾ in.
6 Test tubes, Pyrex or hard glass, 6 x 1 in.
2 Thermometers, chemical, 10°-110° C.
double-scale, also graduated F.
1 Tripod heating stand, about 4 in. in diam. (optional)
1 lb. Tubing, glass, 6 mm. outside diam.
1 ft. Tubing, rubber, 5/16 in. inside diam.
1 Tuning fork

The following is a list of equipment available through National Defense Education Act, Title III. These items are on the State approved Basic Science List and are subject to 50% reimbursement under Kentucky's State National Defense Education Act Program. Many items appear on the suggested List for General Science.

Air pump and plate, Hand
Anemometer, Weather instrument type
Aquairium, 6 gallon
Balance, triple beam
Balance, Dial face demonstration
Balance, Platform
Ball and ring
Barometer, aneroid
Barometer tube
Battery, Demonstration cell, Gotham
Battery jar, 4 pt.
Beakers, 100 ml.
Beakers, 250 ml.

Bell jars
Bottles, narrow mouth, glass stoppers, 16 oz.
Burners, Bunsen
Buzzer, Electric
Camera obscura
Catskin
Chart, Periodic Long Form
Clamps, Burette single
Clamps, Condenser
Clamps, Meter stick
Clamps, Mohr's (pinchclamp)
Clamps, Universal, seivel
Cloud apparatus
Coil, heavy
Coil, induction, large
Compasses, magnetic, 45 mm
Cylinders, water-proofed wood
Density ball
Dishes, Porcelain
Dishes, Culture
Dissecting sets
Dissecting pans
Electrolysis apparatus, simple
Electromagnets, U-form
Electroscope, Flask form
Filter pump (aspirator)
Fire blanket
Fire extinguisher
Fire extinguisher, demonstrator
First aid cabinet, with supplies
Flasks, Florence, flat bottom, 250 ml.
Flasks, Florence, flat bottom, 500 ml.
Flasks, Florence, flat bottom, 1000 ml.
Funnels, glass, 75 mm. diameter
Galvanometers, portable
Germinating box, metal
Globe, blank
Globe, celestial
Globe, terrestrial
Graduated cylinders, 100 ml capacity
Graduated cylinders, 500 ml capacity
Gyroscope
Hygrometer, wet and dry bulb
Insect box
Insect net
Lamp, alcohol
Lamp, electrical, miniature
Lamp chimney
Lenses, set consisting of concavo-convex, convexo-concave, double Concave, double convex, plano-concave, and plano-convex
Liter block, dissectible
Magnets, Alnico, disc
Magnets, Cylindrical, large, pair
Magnets, Horseshoe
Magnet, Bar, alnico, pair
Magnetic needle
Magnetizer
Mat, asbestos
Meter stick, English and metric
Microscope, Compound
Microscope slides
Mirror, Plane, glass, 10 x 15 cm
Model, Lung demonstration
Model, Pump, lift
Motor, St. Louis, with attachments
Needles, dissecting, bent and straight
Power unit, electric
Prisms, Equilateral, lucite
Prisms, Right angle, flat
Prisms, Pin sighting
Psychrometer, sling
Pulley, Block, double
Pulley, Block, triple
Pulley, Block, quadruple
Pulley, Tandem, double
Pulley, Tandem, triple
Ring stands with three rings
Rod, soft glass
Rotator, hand driven, and accessories
Scoopula
Simple machines demonstration
Siphon, intermittent
Slide cover, glass
Sockets, Miniature
Spatulas, steel
Spring, spiral, for wave motion
Steam engine, demonstration model
Steam engine, working model
Stroboscope
Telephone set, receiver, transmitter
Test tubes (specify size)

Test tube supports
Thermometers, Centigrade, Fahrenheit, combined scale
Thermometers, Centigrade
Tubes, Thistle
Tubing, Glass
Tubing, Rubber
Tuning forks, major chord, set
Watch glasses, select by size, 75 mm
Wagon, laboratory
Weights, general laboratory
Weights, slotted, iron, metric

The following is a list of equipment recommended for the usual laboratory experiences conducted in the general biology course. Most of these items are available through Title III of the National Defense Education Act Program and are subject to 50% reinbursement. Most of the items listed below appears on the state approved basic science list.

Biology: Basic

Aquarium
Aquarium Aerator
Aquarium Heater and Thermostat
Aspirator, Filter Pump
Autoclave, Steam Pressure
Balance, Single Beam, Avoirdupois and Metric
Balance, Triple Beam, Low Form, Heavy Duty
Beaker, Griffin, Low Form
Beaker Covers, Watch Glass Form
Binocular, 4x
Binocular, Wide Field
Board, Dissecting, Animal
Board, Spreading, Insect
Boiler, Double
Bottle, Dropping
Bottle, Dropping, Barnes Form
Bottle, Dropping, Polyethylene
Bottle, Dropping, Squat Form
Bottle Stopper Extractor
Bottle, Wide Mouth, Screw Top
Box, Microscope Slide
Box, Tin, Papered or Transparent Lid
Burner, Bunsen
Burner, Propane, Disposable Cylinder
Cabinet, Micro Slide
Cage, Animal
Cage, Animal, Collapsible
Capillary Apparatus
Case, Insect Specimen, Storage
Chart, The Elements
Charts, Anatomy of Man, Froshe
Charts, Biology
Clamp, Meter Stick
Clamps and Tongs
Collection, Fossil
Cork Borer Sharpener
Cork Borers, Hand
Cork Press, Rotary
Counting Chamber, Blood
Cylinder, Graduated
Dish, Culture
Dish, Culture, Moist Chamber
Dish, Evaporating, Porcelain
Dish, Laboratory, Plastic
Dissecting Set, Student
Fire Blanket
Fire Extinguisher, Carbon Dioxide
Fire Extinguisher, Dry Chemical
First-Aid Cabinet with Supplies
Flask, Erlemeyer
Flask, Florence, Flat Bottom
Flower Press
Forceps, Bone Cutting, Screw Lock
Forceps, Bottle and Specimen
Forceps, Sterilizer
Forceps, Straight
Funnel, Short or Long Stem, Fluted
Funnel Tub, Thistle Top
Germinating Box
Heater, Immersion
Hemocytometer Set
Hot Plate, Electric, Three-heat Single Unit

Incubator
Jar, Battery, Cylindrical
Jar, Bell, High, Solid Top
Jar, Laboratory Storage
Jar, Staining, Coplin
Kits
Knife, Retractable Blade
Lamp, Alcohol
Lamp, Microscope, Sub-stage
Magnifier, Coddington
Magnifiers, Pocket, Folding
Mat, Asbestos
Meter Sticks
Microprojector, Low Power
Microprojector with Three Objectives
Microscope, Barnes Dissecting
Microscope, Monocular, Student
Model, Ear, Separable
Model, Eye, Separable
Model, Torso
Model, Torso, with Head
Models, Mitosis, Animal
Mortar, Porcelain with Pestle
Mounts, Botanical
Mounts, Riker
Mounts, Zoological
Needle, Inoculating
Needle, Teasing
Net, Insect, Collapsible
Net, Throw
Net, Towing
Pan, Dissecting
Pins, Insect
Pipet, Transfer
Rod, Glass
Scalpel, General
Scoopula
Slide Cover Glass, Microscope
Slide Warmer
Slides, Microscope, Depression
Slides, Microscope, Plain
Slides, Microscope, Prepared, Botany
Slides, Microscope, Prepared, Zoology
Spatula, Stainless Steel
Speciments, Demonstration, Animal Kingdom
Specimens, Plant Kingdom
Stone, Sharpening
Support Stand, Metal, Ring Stand
Support, Test Tube
Support, Test Tube, Polyethylene
Terrarium
Test Tubes, Borosilicate
Thermometer, Centrigrade, -10° to plus 110°
Thermometer, Soil
Tools
Tube, Culture
Tube, Fermentation
Tubing, Glass
Tubing, Rubber and Plastic
Vasculum
Vials, Different Sizes
Vivarium
Wagon, Laboratory
Wagon, Laboratory, Stainless Steel

Biology: Standard

Ant Nest, Observation
Auger, Soil
Balance, Animal, Triple Beam
Balance, Single Beam, Avoirdupois and Metric
Balance, Triple Beam, High Form
Basket, Test Tube
Basket, Wire
Beaker, Stainless Steel
Bee Hive, Observation
Block, Observation, Cork
Block, Pinning
Board, Dissecting, Animal
Board, Spreading, Insect
Bottle, Balsam
Bottle, Dropping
Bottle Carrier, Safety
Bottle, Dropping, Polyethylene
Bottle, Dropping, Squat Form
Bottle, Glass Stoppered
Bottle, Insect-Killing
Bottle, Polyethylene, with Faucet
Bottle, Reagent, Labeled
Bottle, Washing, Polyethylene
Bottle Vacuum
Bottle Support
Box, Pipet
Box, Relaxing
Box, Specimen, Clear Plastic
Brownian Movement Apparatus

Buret, for Pinchcock
Buret, Straight Stopcock
Cabinet, Micro Slide
Cage, Animal
Cage, Insect
Case, Insect Specimen
Casserole, Porcelain
Centrifuge, Hand Operated
Chart, Periodic, Long Form
Chart, Periodic System, Hubbard
Charts, Life History and Habitat
Charts, Physiology
Clinostat
Collecting Belt, Field
Collecting Sack, Ecology
Crucible Covers, Porcelain
Crucible, Porcelain, High Form
Culture, Glass, Hydroponics
Dish, Crystallizing
Dish, Storage
Dissecting Set, Instructor
Drill, Electric Portable
Flask, Distilling
Flask, Filtering
Flask, Volumetric, Glass Stoppered
Forceps, Bone Cutting, Box Lock
Forceps, Cartilage
Forceps, Cover Glass
Forceps, Curved
Forceps, Insect Pinning
Forceps, Toothed, Tissue
Funnel, Filtering, 60°, Polyethylene
Funnel, Thistle Tube Top, Polyethylene
Germinator, Clay
Glass Cutter, Hot Wire
Hot Plate
Hot Plate, Electric, Three-heat Multiple Unit
Hyrometer, Light and Heavy liquids
Hydroponics Equipment
Incubator
Incubator, Egg
Incubator, Metal Walls
Jar, Staining, Coplin
Kits
Kymograph
Lamp Chimney
Magnifier, Dissecting
Manometer, Sap Pressure Apparatus
Microprojector with Three Objectives
Microscope, Barnes Dissecting
Microscope, Illuminator
Microscope, Monocular with Oil Immersion Lens
Microscope, Monocular, Student
Microscope, Steroscopic
Microtome, Hand
Model, Brain, Dissectible
Model, Brain, Dissectible, in Head
Model, Crayfish, Dissected
Model, Earthworm, Dissected
Model, Flower
Model, Frog, Dissected
Model, Grasshopper
Model, Human Head
Model, Human Heart
Model, Human Lungs and Heart
Model, Leaf
Model, Lung Demonstration
Model, Perch
Model, Propagation
Model, Root Tip
Model, Skeleton, Cat
Model, Skeleton, Human
Model, Skin
Model, Stem, Dicotyledon
Model, Stem, Monocotyledon
Model, Villus, Intestinal
Mounts Biological Specimens, Plastic
Needle, Inoculating
Net, Scraping
Net, Towing
Osmometer
Oven, Drying
Pan, Dissecting Instruments
Pencil, Diamond Point
Pencil, Electric
Photosynthesis Light Screen
Pipet, Blood Diluting, Red Cell
Pipet, Blood Diluting, White Cell
Pipet, Mohr Measuring
Potometer
Probe
Projection Screen
Projector, Film Strip and Slide
Projector, Overhead
Projector, 16 mm, Motion Picture Sound

Pruner, Pocket Size
Punch, Insect Mounting Point
Rack, Test Tube, Wire
Refrigerator
Rods and Support
Scalpel, Cartilage
Scissors, Dissecting, Blue Point
Scissors, Dissecting, Fine Points
Scissors, Dissecting, Blunt and Sharp Points
Skeletons, Representative Vertebrates
Slide Warmer
Soil Test Set
Sphygmomanometer
Spotlight Pointer
Sterilizer, Steam Pressure
Stethoscope
Support Arm
Syringes, Luer
Tank, Distilled Water Storage
Tester, Soil Colloid
Tester, Soil Correction, Slide Rule
Tester, Soil Nitrate
Tester, Soil Phosphorus
Tester, Soil Potash
Thermometer, Dial
Thermometer, Clinical, Oral
Thermometer, Maximum-Minimum
Timer, Interval, Electric
Timer, Interval, Spring Wound
Timer, Stop Watch
Timer, Wall Model, Electric
Top, Heavy Wire, for Animal Jar
Transpirometer
Triangle, Pipe Stem
Trough, Pneumatic
Tube, Fermentation
Vasculum
Watch Glass
Watch Glasses, Syracuse and Embryological
Water Bath, Test Tube, Copper

Biology: Advanced

Auxanometer
Bacteria Colony Counter
Binocular, Wide Field
Box, Rh Blood Typing
Caliper, Bernier
Camera, Photomicrographic
Camera, Polaroid or Equivalent
Centrifuge, Semi-micro Head, Motor-Driven
Chart, the Nuclides
Clasp, Leaf
Cloud Chamber, Diffusion
Color Comparator, PH
Demineralizer, Ion Exchange
Desiccator With Plate
Dish, Staining, Toulon
Dosimeter, Charger, Pocket
Dosimeter, Pocket
Electrophoresis Apparatus, Zone
Flask, Dewar, Silvered
Flask, Dewar, Unsilvered
Forceps, Slide Holding
Galvanometer, Portable
Geiger Counter, Radiological
Hemoglobinometer
Hemometer
Hooks and Chains
Inflating Outfit
Kits
Lactometer
Lamp, Ultraviolet, Demonstration
Leaf Punch
Lifter, Section
Magnifier, Eye Loupe, Binocular
Map, Topographic
Microscope, Micro-Projection with Illuminating Unit
Model, Animal Brains
Model, Jaw
Model, Kidney
PH Meter, Line Operated
Scaler, Utility
Spectroscope, Direct Vision
Thermometer, Pasteurizing
Thermoregulator, Bimetallic
Timer, Clock, Electric, Stop
Transformer, Variable Voltage, Low
Tube, Blood Sugar
Tube, Centrifuge
Tube, Geiger, End Window Type
Tube, Geiger, End Window Type, Thin
Tube, Molecular Demonstration
Water Analysis Unit, Bacteriological
Water Bath, Glass

Additional Equipment for Biology

Balance, Trip Scale, Harvard type
Cages, Animal, rigid
Capillary tubes
Clamps, Burette, single
Corkborers, set
Dissecting pans
Funnels, glass, 75 mm. diameter
Jars, specimen and storage
Magnifier, tripod, mounted
Microscope, Compound
Microscope, slides
Microscope, slides, depression
Model, Mitosis
Mortar and pestle—65-70 mm. diameter
Mortar and pestle—80 mm. diameter
Mortar and pestle—130 mm. diameter
Needles, dissecting, bent, and straight
Net collecting
Pipettes, 10 ml.
Pipettes, 25 ml.
Specimens, Mounted, Plant Group exhibit
Specimens, Mounted, Fossil
Specimens, Mounted, Seed display set
Test tube supports
Towing Net

Suggested Material List for Chemistry

The following list is an estimate of the material advisable to purchase for a class of ten pupils provided each student performs all the experiments usually recommended by the average chemistry laboratory manual. It names a generous supply of apparatus and chemicals, allowing for a reasonable amount of breakage.

In case of somewhat expensive apparatus it has been assumed that two pupils will use one piece of apparatus.

In many schools it is practicable to arrange the laboratory work so that all of the members of the class do not perform a certain experiment at the same time. In such cases, the number of expensive pieces of apparatus required may be less than that mentioned in the list.

An asterisk follows certain items on the list. Such articles are relatively less necessary, as they are usually needed for only a single experiment.

Permanent Equipment

1 anvil, or heavy block of iron.*
5 apparatus, electrolytic.*
1 apparatus, electrolytic, carbon electrodes.*
5 apparatus for testing conductivity of solution.
2 balances, platform, with weights for weighing from 1000 grams to 0.1 gram.
10 balances, horn pan, 7½″ beam, with weights for weighing from 100 grams to 10.01 grams (or equivalent type).
1 barometer.
5 battery tops, porcelain.*
1 blast lamp.
10 blowpipes, 8″.
10 burners, Bunsen.
5 burners, Meker.

15 carbons, arc, ⅜″ diam.
15 cells, dry battery.*
20 clamps, iron, small; for test tubes, burettes, etc.
10 clamps, iron, large; for Liebig condensers.
5 screw compressors.
10 cups, metal, ordinary tin or aluminum.
1 set cork borers, 6 in set.
12 crucibles, porcelain, with lids, #00.
5 crucibles, iron, #0.*
2 crucible tongs.*
12 dishes, porcelain, evaporating dishes #0.
12 dishes, porcelain, evaporating dishes #1.
1 dish, porcelain, evaporating dish, about 10″ diam.
10 files, triangular, 5″.
10 pr. forceps, iron 4″.
10 squares gauze, iron wire with asbestos center, 5″ x 5″.
1 glass cutter.
2 hammers, ordinary.*
10 holders, test tube.
5 lamps, incandescent, 75 watt.
5 magnets.*
5 magnifiers, Coddington lens, or other make.
1 microscope, compound.*
5 mortars, with pestle, 3½″.
12 pans, enamel, shallow, 1 qt.
10 pans, iron, 5 in., shallow form, "sand bath."
10 pinch-cocks, Mohr's medium.*
10 ft. platinum wire, #25.*
10 racks, test tube, for 12 tubes.
5 shears, 6″.*
1 sieve, 60 meshes to the inch.
5 spatulas, horn 6″.
10 spoons, deflagration, diam. of bowl 1 cm.
10 stands, iron, ring, 3 rings.
3 lb. stoppers, rubber, assorted sizes, #0-5, one-and two-hole and solid to fit 8 oz. and 16 oz. wide-mouth bottles.
1 stylus.*
5 teaspoons.
10 thermometers, chemical, 0°-250° C.
10 thermometers, chemical, 10°-220°
10 trays, enameled, long, about 8″ x 12″.*
10 tripods, iron, for supporting dishes over burner, ring 4″ in diam.
10 triangles, pipestem, small stem.
10 troughs, pneumatic.
50 ft. tubing, rubber, inside diam. 3/16″.
20 ft. tubing, rubber, inside diam. ⅜″.
5 yardsticks.*
5 water baths.*
10 wing tips, for Bunsen burners.

Supplies

Ordinarily obtained from Chemical Supply Houses

12 sheets asbestos, very thin (baking sheets).*
12 squares asbestos, 6 x 6″ heavy, about ⅛″ thick.
12 brushes, test-tube.
12 brushes, for small tubes.
2 gross corks, assorted sizes, long, including some to fit wide-mouth bottles.
4 crucibles, sand 2″ diam.
10 pks. filter paper, qualitative, good quality, 4″ diam.
1 pk. filter paper, large, about 10″ diam.
1 pk. wax tapers.
2 pks. wooden splinters, cigar lighters.

Glassware

24 beakers, 100 ml.
36 beakers, 150 ml.
24 beakers, 200 ml.
24 beakers, 250 ml.
12 beakers, 500 ml.
10 bottles, 2 Oz., fitted with rubber stoppers and medicine droppers.*

100 bottles, reagent, 4 oz.
30 bottles, wide mouth, 4 oz.
40 bottles, wide mouth, 6 oz., with two-hole rubber stoppers to fit.
10 bottles, wide mouth, 8 oz., with two-hole stoppers to fit.
5 bottles, wide mouth, 16 oz., with two-hole rubber stoppers to fit.
10 bottles, acid, 2½ liters.
20 burettes, 50 cc., graduated to 1/10 cc., complete.
10 with glass stop-cocks, 10 with pinch-cocks.*
30 cobalt (or equivalent) glass squares, 2½ x 2½″.
10 condensers, Liebig, 15″.*
12 flasks, distilling, 250 ml.*
12 flasks, Florence, 50 ml.
12 flasks, Florence, 250 ml., with two-hole rubber stoppers to fit.
12 flasks, Florence, 100 ml., with one-and two-hole rubber stoppers to fit.
12 flasks, Erlenmeyer, 50 ml.
12 flasks, Erlenmeyer, 150 ml.
12 flasks, Erlenmeyer, 250 ml., with two-hole rubber stoppers to fit.
24 funnels, accurate 60°, 2½″.
10 graduates, 25 ml.
10 graduates, 50 cc., graduation marks to 1 ml.
2 graduates, 1000 cc., graduation marks to 10 ml.
10 jars, battery, about 4″ x 5″.
1 jar, battery, 1 gallon.*
10 jars, hydrometer, 12″ x 2″.
5 pipettes, 10 cc.*
40 plates, glass, 2½″ x 2½″.
10 plates, glass, 4″ x 4″.
40 plates, cobalt glass, for flame tests, 3″ x 2″.*
15 reports, tabulated, with ground-glass stopper, 60 ml.*
1 lb. rods, 3 mm. diameter.
1 lb. rods, 6mm. diameter.
10 spatulas, glass.
10 tubes, gas measuring, 50 ml., graduated to 1/10 ml.
15 tubes, test pyrex, for ignition 6″ x ⅝″, with one-hole cork stoppers to fit.
12 tubes, test, side arm, 6″.*
15 doz. tubes, test, soft glass, medium walls, for heating, 6″ by ¾″.
2 doz. tubes, test, soft glass, medium walls, for heating, 4″ by ½″.
15 tubes, thistle, 10″, stem 3/16″ in diameter.
15 tubes, thistle, small, to fit side-arm test tubes.
2 lb. tubing, soft glass, medium walls for bending, outside diameter 6-7 mm.
1 lb. tubing ½″.
½ lb. tubing, hard glass, ¼″.*
15 U-tubes, each arm 6″.
24 watch glasses, diameter 2½″.
40 watch glasses, Syracuse form, diameter 3″.*
5 medicine droppers.

Chemicals

1 lb. acid, acetic, 30%, c.p.
1 oz. acid, acetic, glacial.*
1 oz. acid, citric, c.p.
4 oz. acid, formic.*
12 lb. acid, hydrochloric, c.p., sp. gr. 1.19.
1 oz. acid, hydrofluoric.*
7 lb. acid, nitric, c.p., sp., gr. 1.42
1 lb. acid, oxalic, cryst., c.p.
1 oz. acid, salicylic.*
9 lb. acid, sulfuric, c.p., sp. gr. 1.84.
4 oz. acid, tartaric.
¼ lb. alcohol, amyl.*
2 qt. alcohol, ethyl, 95% (ethanol).
1 pt. alcohol, methyl (wood, alcohol, methanol.)*
4 oz. alizarine, paste, 25%.*
1 oz. alpha naphthol.*
1 lb. aluminum, sheet, 18 gage.
8 oz. aluminum sulfate, cryst.
1 lb. ammonium chloride, c.p.
8 oz. ammonium ferric citrate (green scales).*

10 lb. ammonium hydroxide, c.p., sp. gr. 0.9.
2 oz. ammonium molybdate.*
8 oz. ammonium nitrate, cryst. c.p.
2 oz. ammonium oxalate, cryst., c.p.*
4 oz. ammonium sulfate, c.p.
2 oz. aniline acetate.
¼ lb. ammonium sulfide.*
1 oz. antimony, lumps, (powder before using).*
1 lb. barium chloride, cryst., c.p.
¼ lb. barium hydroxide.*
4 oz. barium peroxide.
4 oz. barium nitrate, c.p.
4 oz. Benedict's solution.*
2 oz. benzol.*
4 oz. bismuth, metal.*
8 oz. bleaching powder.
1 lb. boneblack.
¼ lb. brass, sheet, 18 gage.*
1 oz. bromine.*
1 oz. cadium nitrate, c.p.*
½ lb. calcite.*
5 lb. calcium carbonate, marble chips.
1 lb. calcium chloride, granular, for drying tubes.
2 oz. calcium nitrate, c.p.
2 lb. calcium oxide, good quality of lime in tin can.
2 lb. calcium hydroxide, hydrated lime.
2 oz. calcium phosphate (monocalcium).*
5 lb. calcium sulfate, plaster of paris, fine.
1 oz. camphor, gum.*
1 lb. carbon disulfide.
1 lb. carbon tetrachloride.*
4 oz. casein, powdered.*
5 lbs. cement, white.*
½ lb. chalk, precipitated.*
10 sicks charcoal.
1 oz. charcoal, wood, powdered.
1 lb. chloroform.*
2 oz. chromium sulfate, c.p. (or chrome alum).
½ yd. cloth calico, bleachable color, for bleaching with chlorine.
1 oz. cobalt nitrate, cryst., c.p.
1 oz. cobalt oxide.*
¼ lb. copper chloride, crystals.
4 oz. copper foil, 1/100″ thick.*
10 sq. in. copper gauge, 80 meshes to inch.*
2 lb. copper rivets, ½″.
½ lb. copper sheet, 1/64″ thick.
2 lb. copper turnings, clear, fine.
1 lb. spool copper wire, #16.
1 lb. spool copper wire, #18.
1 lb. spool copper wire, #22.
1 lb. spool copper wire, #30.
¼ lb. copper nitrate, crystals.*
1 oz. copper oxide, wire form.
1 oz. copper oxide, powdered, c.p.
1 oz. copper sulfate, anhydrous.
1 lb. copper sulfate, cryst, c.p.
1 oz. cotton, absorbent.
1 oz. dextrin.*
1 lb. dolomite.*
1 oz. eosine.*
4 oz. ether.*
1 lb. feldspar.*
2 oz. Fehling's solution, two solutions in separate bottles.
1 oz. fluorescein.*
2 oz. gelatine, powdered.*
8 oz. glucose.*
1 lb. granite.*
½ lb. gypsum.*
1 lb. hornblende.*
4 oz. hydrochinone.*
1 lb. hydrogen peroxide.
1 oz. iodine, resublimed.*
4 oz. iron chloride, ferric, c.p.
2 oz. iron filings, fine, clean.
2 oz. iron filings, course.
¼ lb. iron oxide, ferric, powdered.*
1 lb. iron sulfate, cryst., c.p.
4 oz. iron sulfide, ferrous, in sticks, for H_2S.
2 oz. lead acetate.
¼ quire lead acetate paper.*
½ lb. lead, foil.
1 lb. lead nitrate, c.p.
¼ lb. lead oxide (litharge).*
1 lb. lead, sheet.*
5 lb. lead shot, #10.
½ oz. lithium nitrate.

1 oz. litmus cubes.
½ quire each, red and blue litmus paper.
4 oz. logwood, ground.*
1 oz. magnesium, powder.*
1 oz. magnesium, ribbon.
1 lb. magnesum sulfate, cryst.
¼ lb. manganese chloride.*
2 lb. manganese dioxide, fine, granular, free from carbon.
4 oz. manganese dioxide, c.p.*
¼ lb. manganese sulfate.*
1 lb. mercury.*
1 oz. mercuric nitrate.
8 oz. mercuric oxide, red.
1 oz. mercurous nitrate.
6 sheets (small) mica.*
2 oz. nickel chloride.*
¼ lb. nichrome wire, #18.
2 oz. nylon flakes.
1 quart oil, petroleum, #30 or lighter.
10 grams phenolphthalein
½ oz. phosphorus, red.
1 oz. phosphorus, white.
1 lb. potassium and aluminum sulfate, alum.
4 oz. potassium acid tartrate.
10 oz. potassium bromide.
1 lb. potassium chlorate, cryst., c.p.
¼ lb. potassium chloride.
2 oz. potassium chromate.*
1 oz. potassium and chromium sulfate (chrome alum).*
8 oz. potassium dichromate.*
1 lb. potassium ferricyanide.
2 oz. potassium ferrocyanide.
2 lb. potassium hydroxide, c.u., by alcohol.
2 oz. potassium iodine, c.p.
¼ quire potassium iodide-starch paper.*
2 lb. potassium nitrate, cryst., c.p.
1 oz. potassium permanganate, c. p.
8 oz. potassium sulfate, c.p.
2 oz. potassium sulfocyanate.*
1 lb. pyrite.
1 oz. pyrogalol.*
1 lb. quartz, crystals, one or more large size.*
4 oz. rosin.*
1 oz. rubber tissue.*
1 lb. salt, rock.*
1 lb. sandstone.*
4 oz. silver nitrate, c.p.
1 lb. slate.*
1 oz. soap, castile, powdered.
2 qts. soap solution.*
½ lb. soda lime.*
2 oz. sodium.
4 oz. sodium acetate.
4 oz. sodium aluminum sulfate (sodium alum).
1 lb. sodium bicarbonate, baking soda.
4 oz. sodium bisulfite.*
¼ lb. sodium bromide.*
1 lb. sodium carbonate, cryst, washing soda.
1 lb. sodium carbonate, dry.
8 oz. sodium carbonate, pure, dry.
5 lb. sodium chloride, salt, fine.
2 oz. sodium chromate, powdered.*
1 lb. sodium hydroxide, c.p., by alcohol.
1 oz. sodium iodide (or potassium iodide).*
1 lb. sodium nitrate, c.p.
1 lb. sodium peroxide
8 oz. sodium phosphate, c.p.
2 oz. sodium phosphate (monosodium).*
2 oz. disodium phosphate.*
4 oz. sodium silicate solution.*
2 lb. sodium sulfate, cryst.
1 lb. sodium sulfite, pure, dry.*
2 lb. sodium thiosulfate ("hypo").
½ lb. sodium tetraborate (borax).
1 oz. strontium nitrate, c.p.
2 lb. sulphur, roll.
1 piece orthorhombic sulfur, large crystal.
8 oz. tin, graulated.
¼ lb. tin, thick foil.
½ lb. tin, sticks.*
2 oz. tin oxide.*
1 oz. wool, glass, fine Bohemian.
1 pkg. wool, steel, fine.

½ lb. zinc, sheet.
2 lb. zinc, granulated (or powdered).
2 oz. zinc dust.*
1 oz. zinc nitrate.
8 oz. zinc sulfate.

Materials Procurable in the Household or Ordinary Stores

1 lb. beef fat.*
1 bottle bluing (for washing).*
10 candles, birthday.*
10 candles, common size.
30 or 40 pieces of broken ceramic ware, varied kinds.*
10 chicken bones, clean.*
2 lbs. clay.
1 lb. cotton, absorbent.
1 yd. cloth, cotton, bleached, fine goods.
1 yd. cotton, cloth, colored (easily bleached color)
1 lb. dry ice (solid CO_2).*
4 sheets emery cloth, assorted, fine to medium course.
1 assortment fibers: cellulose, wool, flax, viscose, rayon, mercerized, cotton, hair, jute, hamp, nylon, derivatives, protein fibers, ers, ramie, kapok, tussah, etc.
1 lb. excelsior.*
1 qt. gasoline.*
6 sheets glass, window, about 10 x 14″ or 12 x 16″.
1 bottle India Ink.*
1 lb. iron brads, 1½″.
1 lb. iron nails, 2½″ or 3″.
1 lb. iron, sheet, 18 gage.
1 spool iron wire, #16.
1 spool iron wire, #22.
1 box labels, gummed, small.
12 lamp chimneys, straight edge top.*
12 medicine droppers.
1 yd. muslin, unbleached.
1 pt. molasses.*
12 needles, knitting, large.*
2 pks. needles, sewing, #4.*
1 quire, paper, black.*
2 sheets, large blotting paper, colored (preferable pink, for bleaching).*
2 quires paper, unglazed (typewriter size.)
2 rolls paper towels.
12 razor blades, old.*
1 box rubber bands, assorted smaller sizes.
5 lbs. sand, fine, clean.
4 sheets sandpaper, assorted, O, 1.
1 can scouring powder, household type.*
1 jar silver polish.*
½ yd., silk cloth.*
½ lb. starch, corn.*
1 lb. starch, potato.*
1 box steel wool pads, fine.
2 lbs. sugar, cane.
1 spool thread.*
12 tumblers.
1 ball twine, wrapping, cotton medium heavy.*
1 lb. wood ashes.*
1 wood block, heavy.*
1 yd. woolen cloth.*

The following is a list of equipment available through National Defense Education Act, Title III. These items are on the State approved Basic Science List and are subject to 50% reinbursement under Kentucky's State National Defense Education Act Program. Many items appear on the suggested Material List for Chemistry.

Air pump and plate, Electric, vacuum and pressure
Atom Model Kit
Balance, triple beam
Balance, Platform
Barometer, mercury
Battery, Demonstration cell, Gotham
Battery, Storage

Battery jar, 4 pt.
Beakers, 100 ml.
Beakers, 250 ml.
Beakers, 400 ml.
Bell jars
Blowpipe
Bottles, narrow mouth, glass stoppers, 16 oz.
Bottles, narrow mouth reagent, 4 oz. glass stopper: set of Dil and Conc. HCI, Dil, and Conc. H2SO4, Dil, and Conc. HNO3, Dil. NaOH and NH4OH. No. of sets.
Buret, 50 ml.
Burners, Bunsen
Chart, Electromotive
Chart, Periodic Long Form
Chart, Spectrum
Clamps, Burette single
Clamps, Burette double
Clamps, Condenser
Clamps, Mohr's (pinch-clamp)
Condensers
Corkborers, set
Cork borer sharpner
Crucibles, porcelain with cover
Dishes, Crystallizing
Dishes, Porcelain
Electrolysis apparatus
Eudiometer
Filter pump, (aspirator)
Fire blanket
Fire extinguisher
Fire extinguisher demonstrator
First aid cabinet, with supplies
Flasks, Florence, flat bottom, 125 ml.
Flasks, Florence, flat bottom, 250 ml.
Flasks, Florence, flat bottom, 500 ml.
Flasks, Distilling, 500 ml.
Flasks, Volumetric, 250 ml.
Flasks, Volumetric, 500 ml.
Flasks, Volumetric, 1000 ml.
Forceps, steel
Funnels, glass, 75 mm diameter
Galvanometers, portable
Gas Diffusion Apparatus
Generator, gas
Graduated cylinders, 25 ml capacity
Graduated cylinders, 50 ml capacity
Graduated cylinders, 100 ml capacity
Graduated cylinders, 500 ml capacity
Goggles, plastic
Lamp, alcohol
Liter block, dissectible
Liter case
Mat, asbestos
Meter stick, English and metric
Microscope, Barnes
Mortar and pestle, 65-70 mm diameter
Power unit, electric
Ring stands with three rings
Rod, coiled lucite
Rod, permalloy
Rod, soft glass
Rotator, hand driven, and accessories
Scoopula
Sockets, miniature
Sonometer, simple type
Specimens, Specific gravity, set
Specimens, Specific heat
Spectroscope, direct vision
Spoon, deflagrating
Test tubes (specify size)
Thermometers, Centigrade
Tubes, Thistle
Tubes, Ignition
Tubing, Glass
Tubing, Rubber
Watch glasses, select by size, 75 mm
Wagon, laboratory

Suggested Apparatus Lists for High School Physics

The following lists give the apparatus estimated for the experiments covered in the fundamental course of physics. The number of pieces is based on a unit of eight students, who work in pairs on most experiments. For larger classes, the quantities should be increased, but not proportionally in all cases.

Essential Equipment

Alcohol, denatured	1	gal.
Ammeter, DC, 3 and 15 amp range	4	
Balance, platform (or platform spring scale)	2	
Balance, spring, 250 grams	4	
Balance, spring, 2000 grams	9	
Barometer, per laboratory	1	
Battery top, porcelain	4	
Beaker, 150 ml.	8	
Beaker, 250 ml.	12	
Binding posts, Fahnstock	12	
Binding posts, American form	12	
Bucket, catch	4	
Bunsen burner	4	
Burette clamp	4	
Calorimeter, brass	4	
Can, overflow	4	
Candles, short 6's	1	lb.
Clamp, Bunsen	4	
Clamp, pendulum	4	
Compass, magnetic, 2.5 cm.	4	
Copper sheet, 5 in. x 1 in.	8	
Copper sulfate, crystals	10	lb.
Cylinder, glass, 14 in. x 2 in.	6	
Dry Cells	8	
(Dry cells if no storage battery available)	16	
File, triangular per laboratory	4	
Fish line, fine, silk	25	yd.
Funnel, glass, 5 in.	6	
Glass plate, rectangular, 3 x 3 x ⅜ in.	8	
Glass plate, 60° triangle, 3 x 3 x ⅜ in.	8	
Glass rod, ¼ in. diameter	1	lb.
Glass tubing, 5-6 mm.	5	lb.
Graduates, glass cylindrical, 100 ml.	8	
Half-meter sticks	8	
Hammer, per laboratory	1	
Jar, battery, 8 in. x 10 in.	8	
Knife, pocket, per laboratory	1	
Lamps, incandescent, 120 volt, 60 watt	12	
Lamps, incandescent, 120 volt, 100 watt	12	
Lens, double convex, 10 cm. focus	4	
Lens holder, tall form	4	
Magnet, bar, 6 in.	4	
Meter Stick	8	
Mercury	8	
Pliers, combination gas and cutting per laboratory	5	lb.
	1	

Ring Stand, with three rings	4
Ruler, level edge, 30 cm.	8
Screens, cardboard, 6 in.	4
Screen holder	4
Screwdriver, per laboratory	1
Socket, lamp, mounted with binding posts	4
Steam generator, with top for testing thermometer, brass or glass	4
Storage battery, 6 volt, 100 amp-hr, per laboratory table, if other low-voltage current is not available	1
Test tubes, 4 in. x ½ in.	12
Test tubes, 6 in. x ¾ in.	12
Test tubes, 6 in. x ⅝ in.	12
Test tubes, 8 in. x 1 in.	12
Thermometers, chemical, $-10°$ to $110°$ C.	8
Thread, linen, per laboratory	8 spools
Tinner's snips, 2½ in. cut, per laboratory	1
Tubing, rubber, white, cloth covered, ¼ in. inside diameter, for burners	20 ft.
Tubing, rubber, Cenco 3/16 in diameter, for connections	3 ft.
Tumblers	8
Tuning fork, 256 or 512 v.p.s.	2
U-magnet, 5 cm. between poles, with keeper	4
Voltmeter, DC, 150 and 3 volt	4
Weights, block, 1-500 gram (if platform scales are used)	4
Weights, 200 gram	8
Wire, annunciator, #18	2 lb.
Wire, chromel or other high resistance wire, bare, #18	¼ lb.
Wire, chromel, bare, #22	¼ lb.
Wire, copper, insulated, #22	2 lb.
Wire, copper, insulated, #28	1 lb.
Wire, lamp cord, 2 conductor, #18	2 lb.
Wire, German silver, insulated, #28	½ lb.
Wire gauze, asbestos center	4
Zinc rods for batteries	8

Equipment for Specific Experiments usually listed in most physics textbooks

The teacher should plan his course and then select from the list the additional equipment for the exercises to be done.

Material or Apparatus

Acid, sulfuric	7 lb.
Air thermometer bulb	4
Ammonium hydroxide	2 lb.
Ammonium sulfate	1 lb.
Arc lamp, right angle	1 for lab.
Battery, B, 120 volt.	2

Beaker, 100 ml.	6
Block and tackle, commercial	2
Block, wood, loaded to float	4
Block, wood, 3 x 3 x 1.5 in.	4
Block, or clamp, for holding mirror	4
Boom, wood	4
Bottle, specific gravity	5
Brads	1 lb.
Brass rod, ¾ in.	1 lb.
Car for inclined plane	4
Carbon, electric light, 6 x ½ in.	4
Citric acid	¼ lb.
Clamp, meter stick	4
Clamp, Stone or Milvay	4
Coil, for induction	4
Coil, nichrome wire on sheet mica, about 55 ohm resistance	4
Compass, magnetic, 1 cm.	16
Compass, pencil	4
Copper strip, battery, 4 in. x 2 in.	4
Cork, flat, 2 in. diameter	4
Cylinder, brass or aluminum, about 7.5 x 2.5	4
Electric bell	4
Ether	1 lb.
Filter paper, 4 in.	1 pkg.
Flask, round bottom, 500 ml.	5
Flask, Erlenmeyer, 100 ml.	5
Foot bellows	1 for lab.
Galvanometer, d'Arsonval	4
Glass resonating tube, 15 in. x 1 in.	4
Glass sheet, 2 in. x 6 in.	8
Hydrometer, heavy liquids	2
Hydrometer, jar, glass, 12 in.	4
Hydrometer, storage battery	1 per table
Inclined plane	4
Iron fillings, fine	1 lb.
Jack screw, commercial	2
Knife edge or fulcrum	4
Lamp bank, series, with binding posts	2
Lamp bank, parallel, with binding posts	2
Lamp, oil, alternative to incandescent lamp	4
Lead sheet	5 lb.
Light box, with translucent window (double)	2
Magnet, 2 in. bar	4
Milliameter, 0-10 ma.	2
Mirrow, glass or metal, 4 x 14 cm.	8
Motor, electric, 6 volt, drum armature	4
Motor, electric, St. Louis type	4
Naphthalene	1 lb.
Nickel strip, 3 in. x 1 in.	4
Nickel ammonium sulfate	2 lb.

Paraffin	1 lb.
Pepper shaker, tin	4
Photometer, Jolly, OR	4
Photometer, Bunsen, alternative to Jolly	4
Pipette, 5 ml.	4
Plug, extension, with 6 ft. flexible cord	4
Potentionmeter, radio, 1000 to 5000 ohm 50 watt	2
Potentionmeter, radio, 10,000 ohm	2
Prism, triangular glass, 60°	8
Protractor, cardboard or brass	4
Pulleys, single	8
Pulleys, double	8
Pushbutton	4
Ray board	2 per table
Rod, soft iron, 5 in. x ½ in.	4
Rubber stopper, 1 hole, #6	4
Rubber stopper, 1 hole, #5	4
Rubber stopper, 2 hole, #5	4
Salt, rock	4 lb.
Scale, paper, 30 cm.	100 for lab.
Screw compressor	4
Sodium thiosulfate (hypo)	4 lb.
Shot, lead, small	1 lb.
Socket, radio, 8 prong, octal	2
Spring, for Hook's law	4
Stand, Ampere's law	4
Steam trap	4
Switch, reversing	4
Telegraph relay	1 per table
Transformer, filament for radio, 6.3 volt secondary	2
Tubing, glass, 3-4 mm.	2 lb.
Tuning fork, large about 60 vps	2
Vacuum tube, 6J5, or similar type	2
Vibrograph	2
Watch glass, 3 in.	4
Weights, hook, 10 to 1000 grams	4 sets
Weight, 25 lb.	2
Wheel and axle	4 lb.
Wire, copper, bare, #10	2 lb.
Wire, copper, insulated, #14	1 lb.
Wire, iron, #18	2 lb.

Additional Material for Use in Various Experiments

Aluminum foil
Bolts or other irregular solids
Cardboard
Cardboard box
Coal lumps
Cheesecloth
Cord
Cork stoppers, assorted
Clips
Dry cells, old
Electric heater or other domestic heating device
Flannel

Gillette blades, old
Glass sheet, 2 in. x 2 in.
Glass stoppers, large
Hairpins, wire
Iron sheet
Labels, gummed
Leather
Marble, lumps
Paper, tissue
Paste
Pencils, hard
Pins
Rubber stoppers, assorted
Sandpaper
Scissors
Sheet brass
Silk cloth
Silk thread
Sponges
Ticker tape
Tin plate
Tin, granulated
Toothpicks
Watch springs

The following is a list of equipment available through the National Defense Education Act, Title III. These items are on the State approved Basic Science List, and are subject to 50% reimbursement under Kentuckys State N.D.E.A. Program. Many items appear on the suggested material list for Physics.

Air pump and plate, Electric, vacuum and pressure
Air pump plate with stopcock
Ammeter, A.C. portable 0-2, 0-5 amp.
Ammeter, D.C. portable, 0-2, 0-5 amp.
Ammeter, D.C. portable 0-10, 0-15 amp.
Ammeter, D.C. Triple range
Ammeter, D.C. Milli, Triple range 10/50/100
Balance, triple beam
Balance, Trip scale, Harvard type
Balance, Dial face demonstration
Balance, Platform
Balls, Assorted sets
Bar, compound
Barometer, aneroid
Barometer, mercury
Barometer tube
Battery, Demonstration cell, Gotham
Battery, Storage
Battery jar, 4 pt.
Beakers, 100 ml.
Beakers, 250 ml.
Beakers, 400 ml.
Beakers, 600 ml.
Bell jars
Boyle's law apparatus: J-tube
Brownian movement apparatus
Bucket and cylinder, Archimedes' principle
Burners, Bunsen
Caliper, Micrometer
Caliper, Vernier
Calorimeter
Car, Ballistic
Cathode ray tube, magnetic effect
Catskin
Center of gravity apparatus
Chart, Periodic Long Form
Chart, Spectrum
Clamps, Burette single
Clamps, Knife edge
Clamps, Meter stick
Clamps, Mohr's (pinchclamp)
Clamps, Universal, swivel
Cloud chamber
Coil, helix
Coil, induction box 1″ spark
Coil, induction, large
Collision apparatus
Compasses, magnetic, 15 mm.
Compasses, magnetic, 45 mm.
Composition of force apparatus: Board with spring balances
Cylinders, water-proofed wood

Diffraction Grating
Dishes, Porcelain
Double cone and inclined plane
Dynamo, hand-powered dissectible
Electric Circuit Kit
Electrophorus, large
Electroscope, Braun form
Electroscope, Metal box
Electroscope, Projection
Filter pump (aspirator)
Filters, light, set
Fire blanket
Fire extinguisher, CO^2
First aid cabinet, with supplies
Flasks, Florence, flat bottom, 125 ml.
Flasks, Florence, flat bottom, 500 ml.
Flasks, Florence, flat bottom, 1000 ml.
Flasks, Distilling
Flourescent materials, Minerals, set
Funnels, glass, 75 mm. diameter
Galvanometers, portable
Gas Diffusion Apparatus
Generator, steam
Graduated cylinders, 25 ml. capacity
Graduated cylinders, 50 ml. capacity
Graduated cylinders, 100 ml. capacity
Graduated cylinders, 500 ml. capacity
Heater, immersion
Hygrometer, wet and dry
Illuminator, 110 v
Inclined plane
Inclined plane, mounted on base with pulley and scale
Index of refraction plates
Induction study outfit
Inertia Ball
Interference plates
Inverse square illustration frame
Lamp, electrical, miniature, 1½ v
Lamp, ultra-violet
Lampboard
Lamp, sodium vapor
Lenses, set consisting of concavo-convex, convexo-concave, double concave, double convex, plano-concave, and plano-convex
Linear expansion apparatus, steam jacket type complete with generator
Liter block, dissectible
Magdeburg type air pressure apparatus, Hemispheres, pair
Magnets, Alnico, disc
Magnets, Alnico, circular, pair
Magnets, Cylindrical, large, pair
Magnets, Cylindrical, small, pair
Magnets, Horseshoe
Magnet, Floating magnet demonstration
Magnet model
Magnet, Bar, alnico, pair
Magnetic effects apparatus
Magnetic needle
Magnetic needle, dipping
Magnetizer
Mat, asbestos
Meter, multimeter
Meter, electrical, lecture table
Meter stick, English and metric
Mirror, Cylindrical, concave and convex, metal
Mirror, Plane, glass, 10 x 15 cm.
Mirror, Spherical, concave and convex
Motor, electric, demonstration
Motor, St. Louis, with attachments
Motor, Universal
Optical bench
Optical disk, with accessories
Oscilloscope
Photometer, Bunsen form
Power unit, electric
Prisms, Equilateral
Prisms, Equilateral, lucite
Prisms, Right angle, flat
Prisms, Pin sighting
Pulley, Block, single
Pulley, Block, double
Pulley, Block, triple
Pulley, Block, quadruple
Pulley, Tandem, double
Pulley, Tandem, triple
Pulley and Clamp
Rectifier, Tungar
Reflectors, parabolic, pair

Refraction tank, with protractor
Rheostat, Slide wire, tubular
Ring stands with three rings
Rod, ciled lucite
Rod, permalloy
Rod, soft glass, lb.
Rotator, hand driven, and accessories
Scoopula
Sockets, miniature
Sonometer, simple type
Specimens, Specific gravity, set
Specimens, Specific heat
Spectroscope, direct vision
Spinthariscope
Spring, spiral, for wave motion
String vibrator
Test tubes (specify size)
Test tube supports
Thermometers, Centigrade
Thermometers, Dial type, bimetallic
Timer
Transformer, demonstration
Trajectory apparatus
Tubes, Resonance
Tubes, Thistle
Tubes, Vacuum Kit
Tubing, Rubber, gt.
Tubing, Glass, lb.
Tuning forks, major chord, set
Voltmeter, D.C. triple scale, portable, laboratory type, 1.5-15-150v
Watch glasses, select by size, 75 mm
Wagon, laboratory
Weights, general laboratory
Weights, slotted, iron, metric
Weight hangers, select to support weights
Whistle, Galton's

Audio-Visual Aids:

Available materials for science ranges from complete courses on films to photographs taken by teachers and students. The NDEA is a tremendous help to local school districts in securing visual aid equipment. The adaptation of educational television to the classroom is becoming a reality. All this should provide fresh ideas which should be watched and evaluated by teachers and administrators.

The following audio and visual aids are very helpful in enriching the science instructional program:

I. Motion picture films
Filmstrips
Lantern Slides
Model (Airplane, Rockets, Etc.)
Television, Science Programs
Radio
Recordings
Stereoscope, pictures
Opaque projector, materials
Living and Non-living Specimens
Charts, science
Science Project Books
Bulletin Boards

Science Materials for:

(a) The teacher should select aids which has direct relations to the science lesson.

(b) Visual aids should be selected as per grade level.

(c) Visual aids should enrich the science program and not be used as mere entertainment.

II. (a) The University of Kentucky has a variety of science films which may be secured for use at a small charge.

(b) A series of science films has been donated to the State Department of Education and has been placed in the University of Kentucky's Film Library for use in high school science classes. These films were produced in association with the Educational Testing Service, Princeton, New Jersey, and in assistance of the National Science Foundation. There are ten films in the series, each has a running time of approximately twenty minutes. The titles are as follows:

1. "Visual Perception"
2. "The Worlds of Dr. Vishniac"
3. "Exploring the Edge of Space"
4. "Thinking Machines"
5. "The Mathematician and the River"
6. "New Lives for Old"
7. "Project Mohole"
8. "The Realm of the Galaxies"
9. "The Flow of Life"
10. "Neutrons and the Heart of Matter"